ENGINEERING CONSTRUCTION WEEKLY

MAR 14 1940

ENGINEERING NEWS-RECORD

MARCH 14, 1940

d in this issue is a group of articles on **SEWAGE DISPOSAL PRACTICE**

HILL PUBLISHING COMPANY, INC. • TWENTY-FIVE CENTS, FIVE DOLLARS PER YEAR

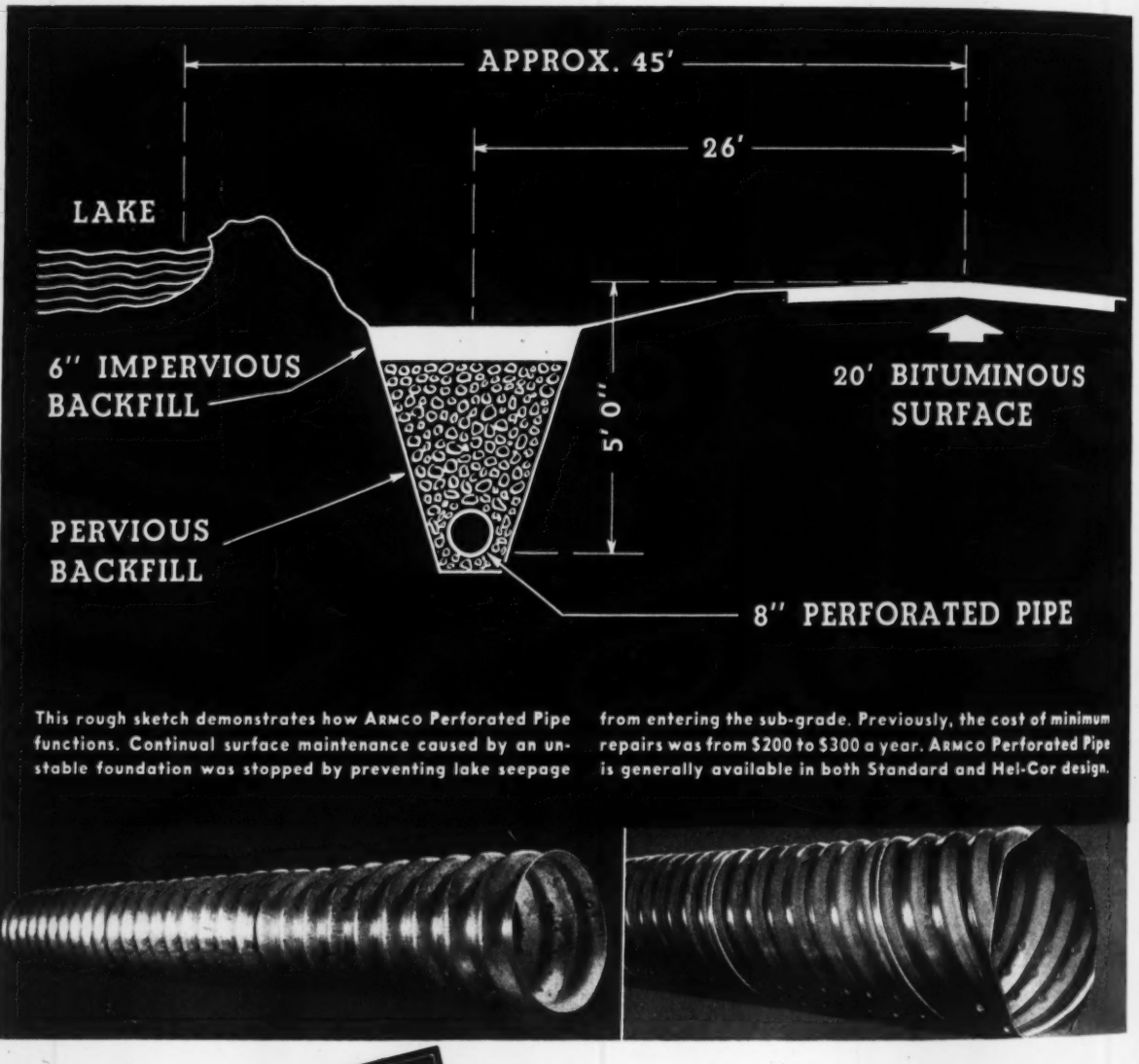
It Stopped the LEAKAGE From A Lake!

• For years surface maintenance was a trying problem on this road by a city reservoir. Permanent repairs were impossible because water seepage from the lake kept the subgrade saturated. Now ARMCO Perforated Pipe drains the water and has eliminated maintenance cost caused by faulty subgrade.

You too can reduce repair bills and add years to the life of your pavements in wet unstable areas. Simply install ARMCO Perforated Pipe. It is easily handled in any length that can be shipped. Once in place the pi[illegible] joined into a co[illegible] strong, tight coupl[illegible] ally designed per[illegible] water freely. Ye[illegible] and other outside[illegible] likely to result [illegible] breakage.

[illegible] ations are [illegible] ons line be[illegible] Scientific[illegible] ions admit [illegible] ting soils [illegible] ers are not [illegible] logging or

If you are tro[illegible] ed by wet unstable foundatio[illegible] an ARMCO Drainage Engine[illegible] will gladly work with you to ke[illegible] your roadbeds dry and firm. Write us for complete information. Armco Drainage Products Assn., 5021 Curtis Street, Middletown, Ohio.



This rough sketch demonstrates how ARMCO Perforated Pipe functions. Continual surface maintenance caused by an unstable foundation was stopped by preventing lake seepage from entering the sub-grade. Previously, the cost of minimum repairs was from $200 to $300 a year. ARMCO Perforated Pipe is generally available in both Standard and Hel-Cor design.

ARMCO PERFORATED PIPE

ORIGINATED AND DEVELOPED BY ARMCO ENGINEERS

ENGINEERING NEWS-RECORD

Devoted to Buildings, Sewers, Waterworks, Bridges, Highways, Streets, Dams, Foundations, Earthwork, Flood Control, Public Works, Irrigation, Canals, Railroads

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THIS WEEK

● The first tied steel arches across the Mississippi River (five spans of them to be exact) will be opened to traffic in June between Rock Island, Ill. and Davenport, Ia. Most interesting structural innovation is the use of a steel H-section for a tie; weighing 1,100 tons, at 398 lb. per ft., the tie material itself would account for a good-sized bridge. The bridge is also notable for being financed without government funds of any kind. And the toll to be charged will be only 10c, which is somewhat of an innovation for Mississippi River crossings.

● From time to time in the past *News-Record* has brought its readers practical articles on salient points of contract law and procedure. In this issue, John W. Gaskins makes some suggestions which will prevent many headaches for contractors doing government work.

● A group of unusually informative articles on sewage disposal practice is included in this issue, highlighted by a story of 40 years experience in providing cooperative facilities for twelve communities in New Jersey. Another article summarizes a wealth of hard-to-get cost data on twenty-four sewer installations. Of special interest is the report on sludge filtration and incineration equipment operation.

THINGS TO COME

PITTSBURGH has gone to work on the traffic problem in its triangular business district by projecting an express belt line around it and starting construction on the south leg along the Monongahela waterfront. This Water St. improvement consists of three parallel roadways, at grade, depressed and elevated, and is not all elevated as shown in an obsolete architectural rendering published in our Feb. 8 issue on p. 205. The work will be described in the next technical issue.

SUPERLATIVES of almost any variety can be applied accurately to North Beach airport, New York City's new municipal air terminal; largest, busiest, most modern, are three that can hardly be challenged. To date no complete account of this great field, its runways, hangars, passenger stations and other facilities, has been published. The March 28 issue will remedy this situation by presenting an article befitting in size, scope and appearance this notable engineering accomplishment that North Beach Airport represents.

Competently written by Lt. Col. Brehon B. Somervell, WPA administrator in New York City, who has guided the destinies of the design and construction, it is an article that no reader should miss.

Let Ryerson Figure the Complete Job

Combined deliveries save Time, Trouble, and Money

SAVE time, trouble, and money by taking advantage of Ryerson's complete steel-service to contractors and builders—a service that includes formed bars, wire mesh, caisson rings, removable forms, and all accessories. You can also secure every miscellaneous steel requirement from structurals to sheets, from steel joists to foundation bolts, from this one source.

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Our special contractors and Builders Division will be glad to work with you on your next job. Whether your problem is one of intricacy of design, large or small tonnage, special service, or limited time, a Ryerson engineer can probably save you time and money. Get in touch with the plant nearest you.

RYERSON STEEL-SERVICE FOR CONTRACTORS & BUILDERS INCLUDES:

- Reinforcing Bars and Accessories
- Spirals, Welded stirrups
- Wire Mesh, Steel Forms
- Road Strip
- Paving Accessories
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- Steel Joists and Accessories
- Beams, Angles, Channels
- Roofing and Siding
- Rails, Shafting
- Boilers Tubes and Fittings
- Turnbuckles, Rivets, Bolts
- Wire, Chain, Tools, etc.

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CONTRACTS AND CAPITAL

ENR CONSTRUCTION VOLUME AND NEW CAPITAL . . . F H A MORTGAGES

(,000 omitted)	February 1939 (4 wk.)	February 1940 (5 wk.)	% Change†	Two Months 1939 (8 wk.)	Two Months 1940 (9 wk.)	% Change†
Total	$203,843	$270,928	+6.0	$515,536	$462,905	−20.0
Private	68,450	98,992	+16.0	119,741	156,274	+16.0
Public	135,393	171,936	+1.5	395,795	306,631	−31.0
Federal	15,261	34,067	+79.0	46,613	55,800	+6.0
Total New Productive Capital	$356,874	$102,545	−77.0	$426,424	$176,453	−63.0
Private Investment	75,736	86,455	−9.0	137,248	115,106	−26.0
Federal (non-federal work)	7,638	16,090	+69.0	15,676	61,347	+248.0
Federal (federal work)	273,500	.....	.....	273,500	.....	.....
FHA Mortgages Selected for Appraisal	$86,213	$84,505	−2.0	$163,807	$155,428	−6.0

† *Adjusted for difference in number of weeks.*

CONSTRUCTION COSTS . . . . WAGE RATES . . . . PRICES

	March 1939	March 1940	% Change	Change February to March 1939 Feb.	1939 Mar.	1939 %	1940 Feb.	1940 Mar.	1940 %
E N R Construction Cost Index, 1913 = 100	234.43	238.29	+1.6	234.31	234.43	+0.1	238.32	238.29	‡
E N R Building Cost Index, 1913 = 100	196.46	201.47	+2.5	196.23	196.46	+0.1	201.50	201.47	‡
ENR 20-CITIES' AVERAGE									
Common Labor	$0.680	$0.685	+0.7	$0.680	$0.680	0	$0.685	$0.685	0
Skilled Labor (Av. 3 trades)	1.435	1.465	+2.1	1.432	1.435	+0.2	1.465	1.465	0
Bricklayers	1.514	1.563	+3.2	1.514	1.514	0	1.563	1.563	0
Struct. Ironworkers	1.530	1.519	+1.3	1.494	1.500	+0.4	1.519	1.519	0
Carpenters	1.290	1.313	+1.8	1.288	1.290	+0.2	1.313	1.313	0
Cement, per bbl	$2.57	$2.59	+0.8	$2.58	$2.57	−0.4	$2.59	$2.59	0
Reinforcing Steel, per cwt.	2.48	2.55	+2.8	2.48	2.48	0	2.56	2.55	−0.4
Struct. Steel, base	2.10	2.10	0	2.10	2.10	0	2.10	2.10	0
Sand, per ton	1.23	1.20	−2.4	1.26	1.23	−2.4	1.20	1.20	0
Lumber, 2x4 Fir, per M ft.	32.55	35.13	+7.9	32.38	32.55	+0.5	35.13	35.13	0
Lumber, 2x4 Pine, per M ft.	29.21	31.89	+9.2	29.15	29.21	+0.2	31.94	31.89	−0.2
Brick, Common, per M	14.00	14.39	+2.8	14.00	14.00	0	14.39	14.39	0
Ready-Mixed Concrete, c.y.	7.13	7.12	−0.1	7.18	7.13	−0.7	7.13	7.12	−0.1
Struct. Clay Tile, 3x12x12	74.48	73.85	−0.8	74.48	74.48	0	73.85	73.85	0
Paving Asphalt, cars, ton	13.75	14.20	+3.3	13.75	13.75	0	14.20	14.20	0

‡ *Less than .05 per cent decrease.*

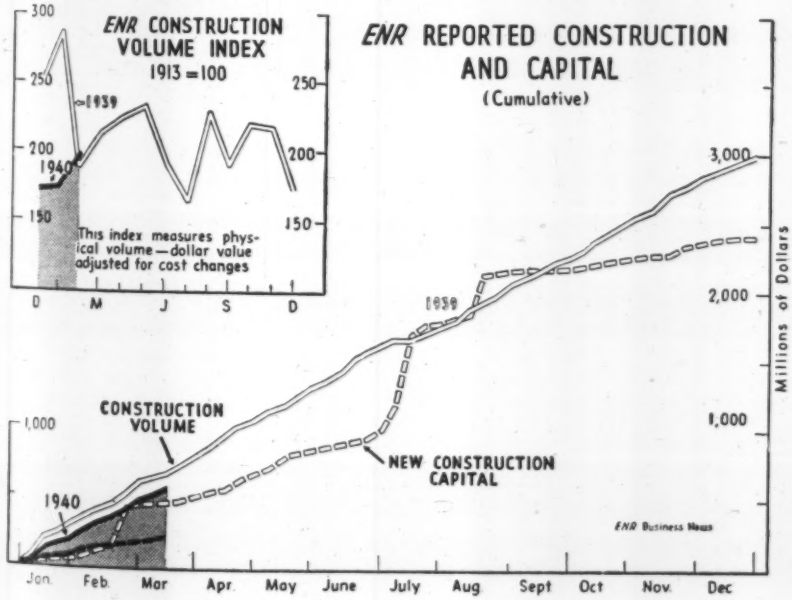
MATERIAL SHIPMENTS . . . . BUILDING PERMITS

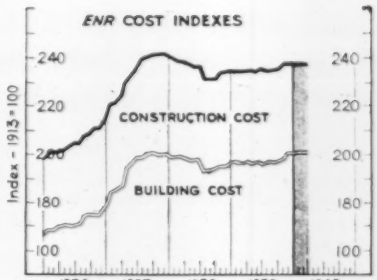
	February 1939	February 1940	% Change	Jan. 1940	% Change Jan.-Feb.
Lumber (% 1929 wk. seas. av.) N.L.M.A.	61.0	71.0	+16.4	78.3	−9.3
Steel (% operating capacity) A.I.S.I.	54.1	70.2	+29.8	83.2	−15.6

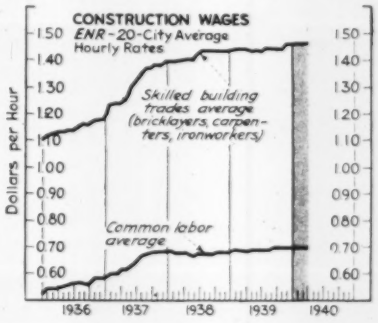
	January 1939	January 1940	% Change	Dec. 1939	Jan. 1940	% Change
Fabricated Struct. Steel, tons, A.I.S.C.	84,281	107,633	+27.6	116,166	107,633	−7.6
Cement, thous. bbl., U. S. B. of M.	5,640	3,889	−31.0	6,791	3,889	−42.7
Building Permits, Dun & Bradstreet, (,000 omitted)	$93,628	$84,632	−9.6	$76,637	$84,632	+10.4

RENT INDEX . . . . EMPLOYMENT

	January 1939	January 1940	% Change	Dec. 1939	% Change Dec.-Jan.
Rent (Housing) Index, N.I.C.B.	86.2	86.6	+0.5	86.6	0
All Trade Unions, % Employed, A.F.L.	Series discontinued Jan. 1, 1940				
Building Trades, % Employed, A.F.L.					







CONTRACTS

(Thousands of dollars)

	Week Ending Mar. 16 1939	Mar. 7 1940	Mar. 14 1940
Federal	$2,000	$2,392	$2,537
State & Municipal	26,942	21,985	26,023
Total public	$28,942	$24,377	$28,560
Total private	17,507	14,931	14,748
TOTALS	$46,449	$39,308	$43,308
Cumulative 1940 (11 weeks)			$545,521
1939 (11 weeks)			$684,165

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial building, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1939 11 Wks.	1940 11 Wks.
NON-FEDERAL	$205,309	$216,747
Corp. securities	32,137	34,186
State & Mun.	132,022	93,894
R.E.A. loans	15,631	.....
U.S.H.A. loans	25,474	88,022
R.F.C. loans	45	645
FEDERAL	$273,500	$ .....
TOTAL CAPITAL	$478,809	$216,747

FHA MORTGAGES

	Week Ending Mar. 11 1939	Mar. 2 1940	Mar. 9 1940
Selected for appraisal	$25,547	$25,483	$26,560*
Cumulative 1940 (10 weeks)			$186,421*
1939 (10 weeks)			$203,413

* Subject to revision.

ENR INDEX NUMBERS

Base = 100	Construction Cost 1913	1926	Building Cost '13	'26	Volume '13	'26
Mar., 1940	238.29	114.55	201.47	108.91	.....	.....
Feb., 1940	238.32	114.56	201.50	108.93	196	86
Jan., 1940	238.34	114.57	201.52	108.94	173	76
Mar., 1939	234.43	112.69	196.46	106.20	210	92
Feb., 1939	234.31	112.63	196.23	106.08	187	82
1939 (Av.)	235.51	113.21	197.44	106.73	211	92
1938 (Av.)	235.86	113.34	196.83	106.40	197	86
1937 (Av.)	234.71	112.66	196.15	106.07	172	75
1936 (Av.)	206.42	99.15	172.18	93.14	185	81

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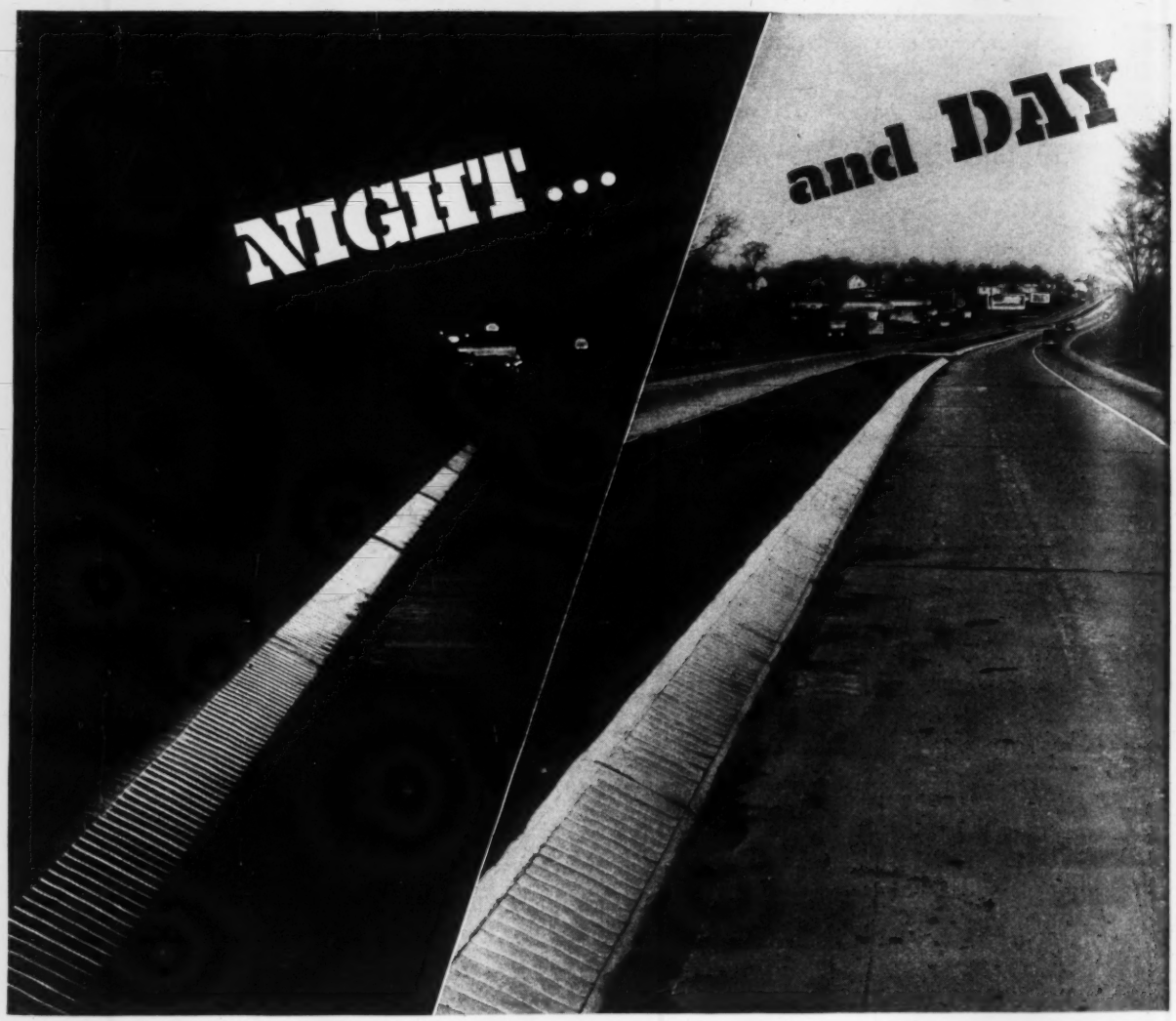
White guide to safety...



White reflecting curb under car headlights and daylight on N. J. Route 25

WHITE reflecting cast-in-place concrete curb, with a finish scored by hand with a steel tool, helps cut down traffic accidents on New Jersey's heavily traveled Route 25.

Here's why! This curbing, developed by the New Jersey State Highway Department and installed by its Maintenance Department, increases driving visibility in good weather or bad—by night and by day.

Its scored surface catches car headlights and reflects the light back to the driver's eyes. Visibility is actually better on rainy nights because the film of water on the reflecting surfaces intensifies both the reflection and the contrast with surrounding objects.

White Reflecting Curb, made with Atlas White portland cement, actually pays for itself in a comparatively short time, because it helps reduce costly traffic accidents and gives a greater degree of comfort to night driving.

To keep traffic moving smoothly —with greater safety—on *your* highways, try White Reflecting Curb, made with Atlas White cement. Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), Chrysler Building, New York City.

NR-M-11

ATLAS **WHITE** PORTLAND CEMENT FOR MARKERS AND CURBS

ENGINEERING NEWS-RECORD

NEWS

Volume 124 MARCH 14, 1940 Number 11

Wyoming Wins Point In Laramie Water Dispute

The state of Wyoming has been permitted by the U. S. Supreme Court to file a petition seeking to have the state of Colorado held in contempt for the alleged excessive use of Laramie River water. Also Colorado has been directed to show cause by Mar. 25 why the state should not be held in contempt for violation of the Supreme Court decree of June 1, 1936, limiting Colorado to 39,750 acre-feet yearly.

• • •

Ask Right to Levy Toll On Westchester Parkway

Officials of Westchester County, N. Y., are preparing a bill for the state legislature that would allow the county to collect tolls on all county-built parkways. The decision to appeal to the legislature follows a ruling by the New York State Court of Appeals voiding the 10-cent toll on the Hutchison River Parkway collected since Aug. 31, 1939 (*ENR*, March 7, 1940, p. 353).

• • •

Grand River Body Signs Contract To Sell Power

The Grand River Dam Authority, Vinita, Okla., has made its first contract with a municipality for the sale of electric power from Grand River Dam. A contract has been signed with the town of Chelsea whereby the authority will take over the present distribution system in Chelsea to sell power, with rates to vary from ¾ to 5¢ per kwh. The authority will also pay a franchise tax of $400 monthly to the town, which now has a municipal plant as the source of power.

Grand River Dam is virtually ready for the filling of the lake behind the dam. The project is expected to be completed in advance of the June 30 deadline although, on March 12, Gov. Phillips of Oklahoma ordered the National Guard to block the work until PWA met his demands for damages to roads and bridges.

Milwaukee to Reopen Sewage Patent Case

The city of Milwaukee plans to petition the federal circuit court of appeals at Chicago to reverse the judgment favoring Activated Sludge, Inc., in the Milwaukee sewage patent infringement case, according to an announcement made last week. The federal judge has authorized the city sewage commission to withhold the final installment of payment of $203,000 of the $818,000 being paid to the company. The judgment was handed down July 22, 1938, after ten years of litigation, the court ruling that $818,000 was to be paid in four installments.

The new plea is based on the sewage patent infringement case pending in Chicago (*ENR*, Oct. 26, 1939, p. 519) against the Chicago Sanitary District. In the Chicago case the court ruled that the patent was valid and that there had been infringement of the patent rights, but litigation has only reached the accounting stage.

• • •

Charles N. Monsarrat Dies; Canadian Consultant

Charles N. Monsarrat, 68, consulting engineer of Montreal and one of the outstanding bridge engineers of the Dominion, died Mar. 1 in that city. Partner in the well known firm of Monsarrat and Pratley, consulting engineers, Monsarrat had been consultant for the Canadian National Ry. since 1921. He was connected with the engineering department of the Canadian Pacific Ry. from 1890 to 1911, chairman of the board of engineers for the Quebec Bridge from 1911 to 1918, and consulting engineer to the Canadian federal government from 1918 to 1921. Monsarrat had served as consulting engineer on the construction of the Jacques Cartier Bridge in Montreal, the Ambassador Bridge at Detroit, the Thousand Islands Bridge in New York, the First and Second Narrows bridges at Vancouver, B. C., and the Ile d'Orleans Bridge at Quebec.

RFC Promises Loan For Battery Tunnel

Total cost is $57,000,000 with city and Triborough Bridge Authority spending $23,000,000 more for approaches

Announcement was made on Monday, March 11, that the Reconstruction Finance Corp. is willing to loan the New York City Tunnel Authority $57,000,000 at 3½ per cent for a vehicular tunnel from the Battery in Manhattan to Hamilton Ave. in Brooklyn. Negotiations have been underway ever since last July when the War Department refused a permit for a bridge at this location. A tunnel had been proposed as early as 1929 but attempts at financing repeatedly failed.

Present plans contemplate a twin tube tunnel some 10,000 ft. long on a curved alignment that would touch Governors Island at about mid length. The R.F.C. loan would cover only the cost of the tunnel proper. Approaches in Manhattan, estimated to cost about

(Continued on p. 39)

• • •

Use of Ready Mix Concrete Investigated in Chicago

To determine why ready mix concrete is not used in the Chicago area as in other large cities, Special Assistant Attorney-General Leo F. Tierney in charge of the federal investigation of construction, has subpoenaed teamsters unions and officials, leading aggregate producers, contractors associations and state and national architectural institutes in that city. It has been charged that unions have prohibited the use of ready mix concrete in the Chicago area and that they called a strike in 1938 when an attempt was made to introduce ready mix concrete on a job. Subpoenaes ask that firms and associations named in the petition produce correspondence with labor leader Michael Carozzo of the Hodcarriers and Building Labor Union.

New Mexico May Sue Colorado Over Pollution

The state of Colorado and the city of Durango, Colo., have been warned that the New Mexico interstate streams commission will begin court action unless pollution of the Animas River in southwestern Colorado is halted. Benjamin V. Howe, sanitary engineer for the Colorado state board of health, says he has been informed that the city plans to construct a sewage disposal plant to prevent further pollution.

• • •

Toledo Edison Plans $4,250,000 Expansion

The Toledo Edison Co. is planning a $4,250,000 expansion program, including installation of 50,000 kw. of turbo generator equipment at Acme power plant in Toledo, Ohio. This will bring plant capacity to 240,000 hp. Plans are also being prepared for an overhead line substation and other improvements.

Work will begin as soon as approval is received from the Security and Exchange Commission at Washington, D. C., and from the Ohio State Utilities Commission.

• • •

Highway Fund Transfer Halted in South Carolina

The Supreme Court of South Carolina Feb. 27 ruled that the diversion of $2,000,000 from the highway fund to the state treasury for current expenses is violation of the state constitution. It was proposed to issue $1,546,000 highway certificates of indebtedness which were to be amortized out of motor vehicle taxes and to transfer $454,000 in cash.

"It may be conceded that the legislature has plenary power in connection with the imposition of taxes to change its mind from year to year as to the purposes to which in each year it will apply the proceeds of particular sources of revenue (in the absence of any question of impairing the obligation of a contract); but under the present constitutional provision it is without power to impose a tax for a particular purpose and before such purpose has been accomplished to change its mind and direct the revenues derived from the particular tax to an entirely different purpose," the court stated.

• • •

Philadelphia to Vote On Large Water Job

The city council of Philadelphia has ordered that the proposed loan for an $18,000,000 improvement to the city's water supply system be voted on at the April 23 primaries. The sum will provide for rehabilitation of the city's filter beds, pumping stations and distribution lines. No new source of supply is planned.

Morris Knowles, Inc., Pittsburgh sanitary engineers, have been hired as consultants for the improvement.

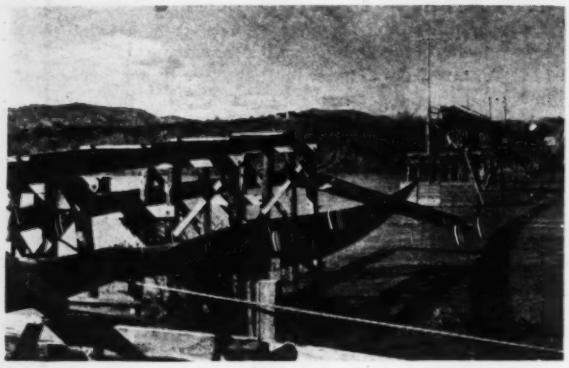
WHAT CALIFORNIA FLOODS DID IN THE SHASTA DAM AREA

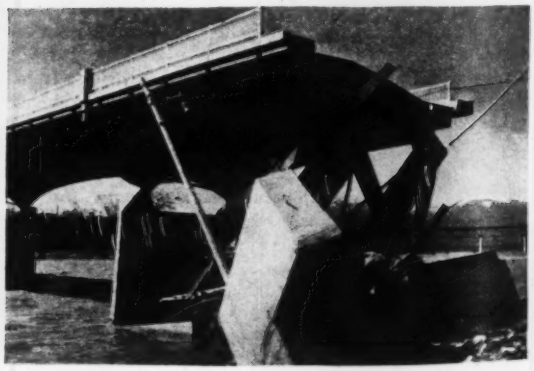
The Sacramento River at flood two weeks ago, following 8 in. or more of precipitation in 24 hr. at several points in northern California, found engineering structures near the Shasta Dam site particularly vulnerable.

At the right is shown what happened to the bridge built just downstream from the site by Pacific Constructors, general contractor for the dam. On the hill in the background is the belt conveyor that carries aggregate to the concrete mixing plant on the west abutment.

In the lower left hand view is shown how the belt conveyor built by the Columbia Construction Co. a mile downstream from the dam site to transport sand and gravel across the river for the dam was damaged.

The wrecked highway bridge shown at lower right spanned the river at Redding.





BRIEF NEWS

THE AUDITOR of the state of Arkansas has been ordered to issue a warrant for $119,000 to purchase the last two toll bridges in the state of Arkansas and located at Powhatan and Des Arc.

THE LARGEST road building program ever carried out in Georgia is expected this year, $6,000,000 having already been released for immediate use and a total of $17,000,000 being available. At present $18,000,000 in new construction is under way with 1,510 mi. of highway involved.

A PRINCIPAL CHANGE in the system of marking highways in Ohio is the adoption of the double no-passing barrier lines in place of the single white line that has been used in the past, according to Harry Neal, chief engineer of the traffic bureau of the Ohio State Highway Department. The double lines will be used on hills and curves and at other points where operators do not have a clear vision of 600 ft. The system has been recommended by the American Association of State Highway Officials for uniform use throughout the country.

A TOTAL of 1,783 mi. of branch lines were abandoned by American Railways in 1939, according to George E. Boyd, associate editor of *Railway Age*. This is a decrease of 114 mi. as compared with 1938.

THE INDIANA state department of conservation will soon begin to operate under a 1939 law which permits it to take over "lost land." Most of this area is hill land in the southern part of the state, much of it having gone tax-delinquent for years. About 180,000 acres are involved and only land useful in the development of state property will be taken over.

ABOUT $6,100,000 will be spent by Mexico this year on highway work, roughly three-fourths of the amount to be for construction and the remainder for maintenance.

A ZONING PLAN giving the Maryland State Road Commission the right to limit the construction of commercial stands and service stations along certain highways has been placed before the State Legislative Council.

• • •

Private Facilities Bought for Bonneville Power System

Power transmission facilities of the West Coast Power Co., which operates in Pacific and Wahkiakum counties, Washington, have been acquired by the Public Utility Districts of the two counties and the Bonneville project to become a part of the Bonneville transmission system. The transaction involves $575,000, 80 mi. of transmission lines in the two counties, a submarine cable across the Columbia River and four substations being added to the Bonneville project at a cost of $155,000. It has been agreed that until the Bonneville transmission system is functioning, the two counties will operate that portion of the Bonneville administration's purchase as part of their own system.

Tuttle and Seelye Form Partnership

Arthur S. Tuttle, consulting engineer of New York City, and Elwyn E. Seelye, of Elwyn E. Seelye & Co., New York City, have formed a partnership for general consulting work. For nearly 20 years Tuttle was chief engineer and consulting engineer for the New York City Board of Estimate and Apportionment, and since his retirement has been state engineer and state director for PWA in New York and most recently consulting engineer for WPA. Seelye has been connected with prominent structural jobs in New York for many years.

• • •

New York Tunnel

(Continued from page 37)

$12,000,000, would consist of separate exit and entrance tunnels under Battery Park and a connection with the West Side Express Highway; also a branch entrance tunnel that would provide access from the East Side of Manhattan. Approaches in Brooklyn, also to cost about $12,000,000, would be built by the Triborough Bridge Authority, it is reported as toll-free facilities. They will encompass a highway from the tunnel portal to a connection with the Belt Parkway in Owl Head's Park and include a high level bridge over the Gowanus Canal.

Construction is estimated to take four years. At the outset a traffic of 9,000,000 vehicles a year is counted on, tunnel capacity being 16,000,000.

SPRING TO BRING KINGSLEY DAM WORK OUT OF HIBERNATION

FOLLOWING a winter shutdown necessitated by a freeze up of core pool and borrow pits, a resumption of pumping activities for the 26,000,000 cu.yd. of hydraulic fill for Kingsley Dam on the North Platte River near Ogallala, Neb., is expected this month or as soon as ice conditions permit. The view above shows conditions shortly before the shutdown.

Two 30-in. electric dredges will pump sand and gravel fill from upstream and downstream borrow pits, the dam to be built to a height of 160 ft. above the river bed. The pump boat in the core pool is equipped with two 18-in. centrifugal pumps driven by electric motors which force water to the top of the south abutment, where additional core material is dumped into a sluice box and returned to the core pool by a third pump similar to those on the barge. During construction river flow is diverted through a spillway conduit temporarily extended a short distance upstream from the 101-ft. diameter morning-glory spillway tower, which may be seen connected by a bridge to the outlet control tower at the left.

The Minneapolis Dredging Co.-Martin Wunderlich Co. is building Kingsley Dam for the Central Nebraska Public Power & Irrigation District, of which George E. Johnson is chief engineer and general manager. George N. Carter is resident engineer at the dam, and George P. Leonard is general superintendent for the contractor.

Robbing Mine Supports May Have Caused Shenandoah Subsidence

Mine operators deny unofficial charges that removal of supporting pillars led to surface settlement of 11-acre section of Pennsylvania borough. Little chance for damages as people hold "surface rights" only

By Edward J. Cleary
Associate Editor

The bottom literally dropped out from under a section of Shenandoah, Pa., on March 5, whereupon the nation's attention was drawn to what is said to be the biggest mine subsidence ever to occur in a densely populated area. No lives were lost when an 11-acre section of this town of 21,000 population suddenly settled as much as 22 in. in the dead of night, but scores of homes and buildings were twisted and cracked, gas and water connections were wrenched loose, and pavements were split open.

The cause was the cave-in of coal mine workings which honeycombed the subterranean region some 400 ft. below the surface. Why the cave-in occurred when it did is a matter of conjecture and dispute. Investigation by state and local officials as well as by private interests are under way but no official statements have been made. A report of state mine inspectors has been given to Gov. Arthur H. James, but it has not been made public.

Unofficial charges have been made, however, that recent mine operations have been "robbing" the supporting pillars of coal which were originally left in place to prevent surface cave-ins. This has been denied by the companies who own the fields, and by operators who hold leases for the mining of coal.

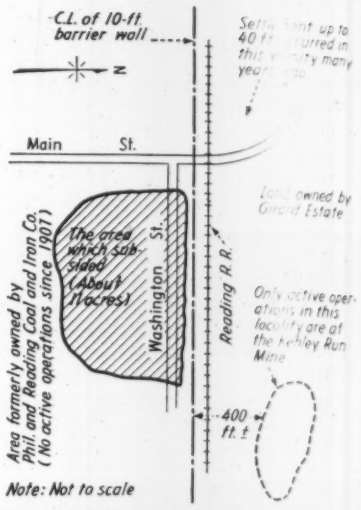
Fear of what may follow in the way of further subsidence, rather than despair over what has already happened sums up the situation as it existed in Shanandoah at the time of this writer's visit late last week. That, and the apparent futility of obtaining legal redress for damages sustained—estimated variously at from $600,000 to $1,000,000—were uppermost in the minds of citizens and local officials.

Subsidence is common

Certain press and radio accounts notwithstanding, Shenandoah is not lying in ruins, nor was there any general evacuation of the affected area. Without minimizing the seriousness of the situation, mining engineers pointed out that ground subsidence is fairly common in this anthracite region. However, the settlement of large areas in the past has generally taken place in regions where few people have been affected.

For instance, in one locality of Shenandoah, the surface has settled more than 40 ft. over a period of years, according to E. H. Rathsburg, building supply dealer. One householder, pictured in an accompanying illustration, has jacked up his home at various times for a total of 39.5 ft.

The area in which the subsidence occurred is about one-half mile from the business center, and is occupied chiefly by small homes of frame construction. There are also a few warehouses and business buildings of brick construction, none over four stories in height. The brick structures, as shown in the accompanying photographs, fissured and cracked, while most of the frame buildings were twisted and caused to sag. Damage on the interior of the buildings was quite severe as evidenced by breakage of plaster surfaces, and the separation of window frames and doors from the framing. No buildings have collapsed, but several have been shored.


C.L. of 10-ft. barrier wall
Main St.
The area which sub-sided (About 11 acres)
Washington St.
Reading R.R.
Area formerly owned by Phil. and Reading Coal and Iron Co. (No active operations since 1901)
Only active operations in this locality are at the Kehley Run Mine
400 ft.±
Note: Not to scale

Schematic sketch of abandoned and present mine workings in relation to the settled area in Shenandoah.

Water service maintained

Public works officials in Shenandoah were prepared for ground settlement. Streets are paved with flexible bituminous materials. Water mains are valved to isolate small sections when leakage develops, and service lines are installed with sufficient slack

Wide World Photo

At Shenandoah, Pa., John Lawson shows how he has arranged permanent jacking facilities to compensate for mine cave-ins under his property. Subsidence such as occurred last week is an old story to Lawson, and during the last twenty years he has lifted his house 39.5ft.

to compensate for ground movement.

This city has the distinction of being served by both a public and private water company, the latter having two supply lines leading into town from spring sources. Almost every street has a dual main system available for domestic service as well as fire protection. In talking with Harvey Scheller, superintendent of the borough waterworks and with Thomas Wragg, superintendent of the Citizens Water Co., the writer learned that relatively few house services were disturbed by the man-made earthquake. In cases where services were broken, regular maintenance crews were able to handle the work so that water was available within a few hours. Shenandoah was not without water as some reports stated.

It is expected that joints in some mains will have opened up and need repair, but thus far no serious leakage has been noted either by visual inspection of the ground, from decreased pressure, or through increased consumption demands.

Breakage of gas main connections constituted the greatest hazard, but quick action by the local office of the Philadelphia Light and Power Co. in closing off leaking pipes minimized dangers. All persons in the affected area were requested to keep cellar windows open to permit the escape of gas in the event of further pipe breakage.

The sketch on this page, made from a map of the northeast part of Shenandoah superimposed upon a mine map, indicates how this area is honeycombed with coal workings. The cross-hatched sections are the "pillars" or columns of coal which were left in place to support the ground. These workings are said to be about 400 ft. below ground. Operations originally carried on here by the Philadelphia & Reading Coal & Iron Co. were abandoned more than 30 years ago, and it is reported that the excavated portion is filled with water.

One active area

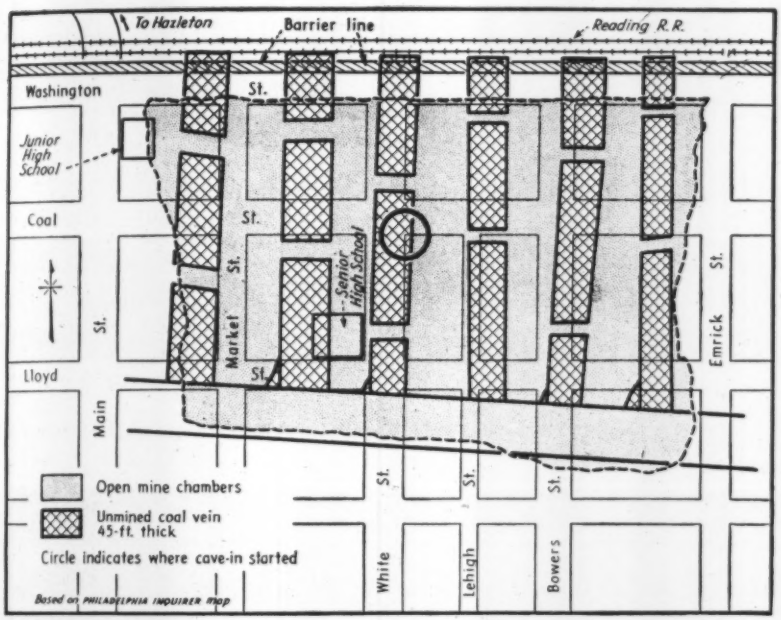
Separating the former P. & R. C. & I. Co. holdings from the land and mineral rights to the north, which are owned by the Girard Estate, is a barrier line or wall of unmined coal. This wall is about 10 ft. thick and was left in place by mutual agreement between the two companies to act as ground support. As shown on p. 40 the only active mining area is reported to be at the Kehley Run Mine on the property of the Girard Estate, at some distance from the caved-in section.

Officials of the Kehley Run mine, which is leased from the Girard Estate, denied that their operations could have influenced settlement in the affected area. The denial was made because of charges that the barrier pillar had been "robbed" and had thus weakened ground support.

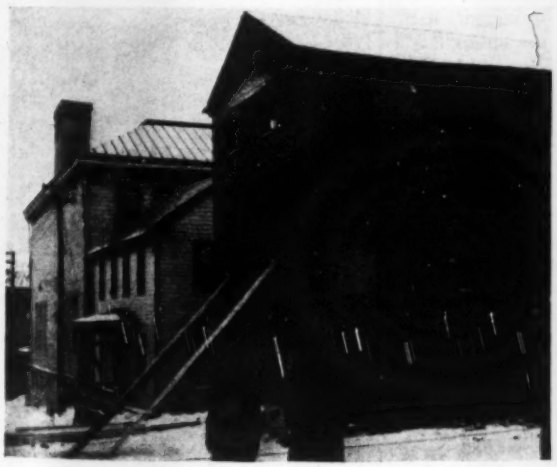
Citizens seek redress

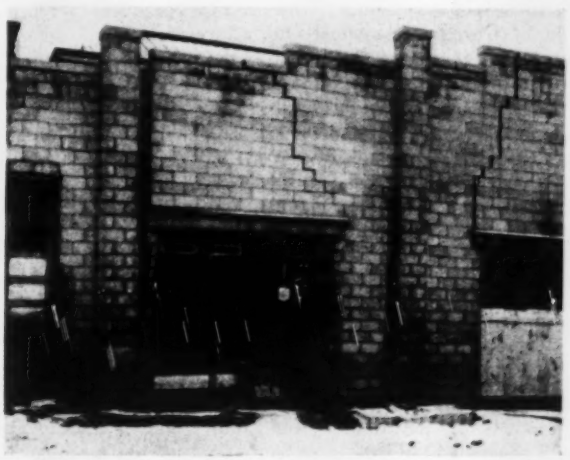
A protective association has been formed by property owners in an effort to place responsibility for the subsidence and to collect damages. It is

(Continued on page 42)



Where the subsidence occurred in Shenandoah. This sketch of the northeast part of the borough is superimposed on a mine map and shows how the subterranean area is honeycombed with coal mine workings.





Brick warehouse (left) which sagged and then began to crumble away where the foundation settled. At the right is a concrete block garage which was badly cracked on all four sides.

Farnsworth Gets Contract For New Orleans Housing

Contract for the construction of the Lafitte Ave. slum clearance housing project at New Orleans has been awarded to R. P. Farnsworth & Co. on a base bid of $3,062,000. The project will provide for the accommodation of 896 negro families.

Bids for the sixth and final slum clearance project in New Orleans will be opened by the New Orleans Housing Authority on Mar. 21, this work being known as the Iberville project. Bids were originally to be opened Mar. 7.

• • •

Tolls On Merritt Parkway Paid by 3½ Million Cars

Toll collectors on the Merritt Parkway Feb. 25 witnessed the passing of 3,400,000th car to pay the 10-cent toll which has been in effect over 35 weeks. Feb. 15, when traffic was small due to a blizzard of the preceding day, toll collections numbered 1,288. The heaviest single day of traffic was Labor Day when 39,855 automobiles paid the toll and established a record hour of 3,181 cars. The maximum for any one month was for July when 594,213 motorists paid.

Income from tolls between June 21 and Jan. 31 amounted to $320,644; net receipts after expense deductions totalled $280,000, the money to be used in the construction of the new Wilbur L. Cross Parkway.

• • •

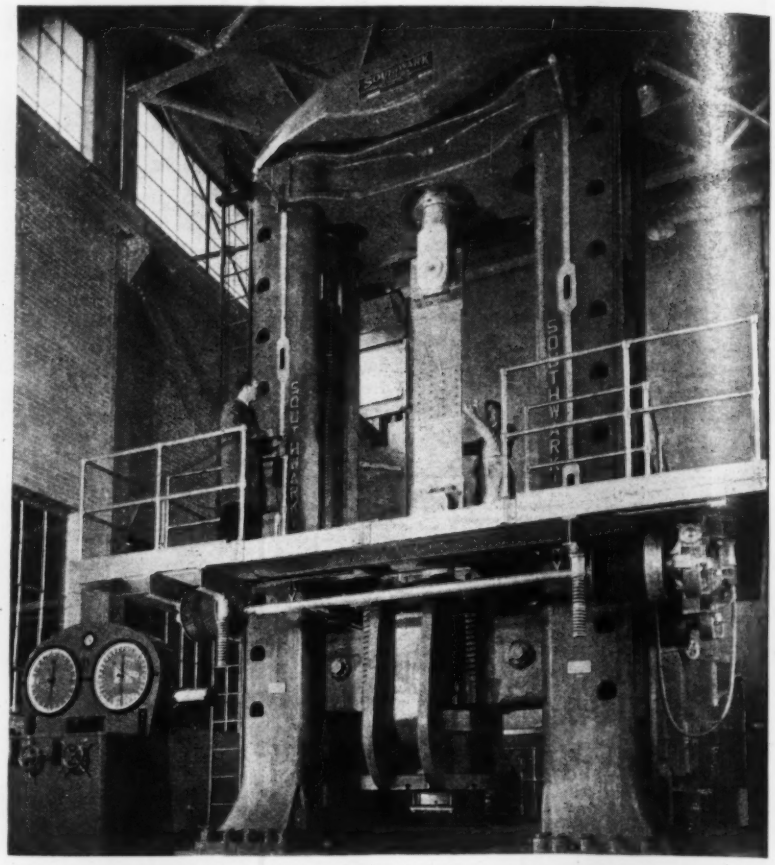
Shenandoah Subsidence

(Continued from page 41)

admitted that this will be difficult, because practically all deeds and leaseholds in this area carry a clause which specifically exempts operators from liability for any damage caused by mining. Gov. James himself said, after a visit to the area, "The rights of the people are like a fleeting cloud. They build their homes at their own risk. The operators have the unqualified right to mine and remove."

Subsidence has halted only temporarily, according to mining experts, and it is expected that further settlement will occur over a period of weeks. In the meantime state building inspectors are examining all structures used by the public and thus far have condemned eleven structures as unfit.

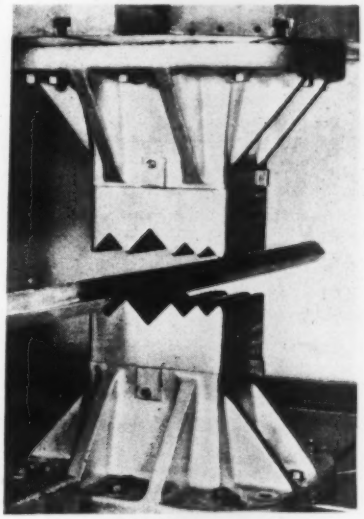
A citizen's association is seeking to obtain an injunction to prevent further operations by the Kehley Run Mine until a complete investigation has been made as to alleged irregularities in mining operations.



MOST POWERFUL TESTING MACHINE GOES INTO RESEARCH SERVICE

SCIENTIFIC and engineering notables in attendance at the inauguration on March 2 of a 1500-ton Emery testing machine at the New Kensington (Pa.) research laboratory of the Aluminum Corp. of America saw it squeeze a 7 x 7-in. billet down to 2 x 2-in. size as a demonstration of its research possibilities. While the machine can crack eggs and break the crystal of a watch without harming case or works, such performances will not be included in its practical services. Its principal use, aside from determining the strength of full-size structural members, will be for investigating pressures and other factors of press-forging and extrusion.

The machine stands 40 ft. 4 in. high, 15 ft. 4 in. of this being below test floor level. Its maximum frame gaps are 7½ x 15½ ft. for compression and 7½ x 12½ ft. for tension, with corresponding loading capacities of 3,000,000 lb. and 1,000,000 lb. Built by Baldwin-Southwark Co., it has a hydraulic press to apply the load and a hydraulic capsule to measure it. Pressure is provided by two pumps driven by 25- and 300-hp motors respectively; the larger unit is able to give the traveling head of the machine a speed of 36 in. per minute under maximum load.



While two Emery machines have larger load capacity—the University of California machine with compression and tension capacities of 4,000,000 and 3,000,000 lb. respectively, and the University of Illinois machine with 3,000,000 lb. capacity in both—the high head speed of the New Kensington machine makes it the most powerful testing machine in existence.

New York Contractor Gets $242,000 for Extra Work

The court of claims of the state of New York has granted the trustee of the estate of the John Johnson Construction Co., Buffalo, N. Y., a judgment of $242,000 against the state of New York for extra work done in 1933 and 1934 at the Harlem Valley State Hospital.

Executives with the John Johnson company contended that numerous additions, substitutions and alterations in the construction contract had involved expenditures and material labor costs not agreed to by the state and the construction company when the contract was signed. A total of $1,176,000 had been asked as extra remuneration.

Bids Asked for First Unit Of Colorado Tunnel

Invitations for bids for construction of an 8,000-ft. section of the 13-mi. Colorado-Big Thompson tunnel were issued by the Bureau of Reclamation March 8, bids to be opened April 8 at the Denver office. The work involves only the excavation, grouting and permanent timbering.

Specifications call for the work to start within 30 days after the contract is awarded; 430 calendar days are allowed for construction.

This is the third time bids have been asked, those received July 22 and Sept. 21 having all been rejected because of insufficient competition. The earlier bids were for the entire length of the tunnel.

Rudy Arnold Photo

IN FIVE MORE DAYS THE SPRINKLERS WOULD HAVE BEEN INSTALLED

North Beach Airport, New York City's great municipal field, was the scene of a spectacular fire on March 5 which destroyed half of a nearly completed hangar. Although of fireproof construction the hangar was full of scaffolding upon which the flames fed. Ironically, the scaffolding was being used to install the sprinkling system, which would have been in operation in 5 days more. Painters and electricians were also at work in the building.

The hangar, a duplicate of 5 others at the field, is of tremendous size, 350 ft. across the front and 165 ft. deep. Because of a fortunate arrangement of roof framing, by which the hangar is divided into two separate structures, only the half in which the fire occurred collapsed. In the view above the main carrying truss for the undamaged half is shown intact; two diagonals probably will have to be replaced or strengthened. The directly adjacent companion truss for the wrecked half of the hangar was pulled down by the longitudinal roof framing when the wall at the right collapsed. Its front-end supporting column was also wrecked.

The fire, which was discovered about 5 p.m. just after the workmen had quit, is believed to have started in a wooden locker in which painters' overalls were hung. New steel is being fabricated, and the hangar will be completed by June 1, about six weeks late. It will be leased by Transcontinental & Western Air, Inc. North Beach Airport, greatest of WPA projects, is unexcelled in size or equipment anywhere in the world. The first complete engineering story on it will be published in *Engineering News-Record* in the March 28 issue.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

For continuation of work on the Colorado-Big Thompson project between now and July, the Senate appropriations committee added $1,000,000 to the First Deficiency Bill as passed by the House. This bill, which provides funds for use during the present fiscal year additional to those regularly appropriated, contains, as passed by the House, $15,517,000 to prevent slowing up of the Central Valley, Grand Coulee, Rio Grande, and Boulder projects and to speed up the San Diego Harbor job.

The President is putting pressure on the Senate to get money for starting the third set of Panama locks inserted in the War Department civil functions appropriation; the House struck out $15,000,000 for the $277,000,000 job. Last week Senate majority leader Barkley said that the House rejection was based on the belief that work could not be started until the plans are completed two years from now; he said that if an investigation indicated that this belief is incorrect the money "undoubtedly would be granted." Canal officials have been insisting for some time that they were all ready to start work—that the unfinished portion of the plans involved details that won't enter the construction phase for some years.

The Interior Department appropriation bill passed the House last week with few changes from the recommendations of the appropriations committee. In accordance with a supplementary budget request, $500,000 was added to the money for the Provo project in Utah, bringing the amount for this project to $1,250,000. This would permit starting work on the Duchesne Tunnel. Eliminated was an authorization to incur $2,000,000 in contract obligations on the Natchez Trace Parkway, leaving an appropriation of $2,000,000 for this and the Blue Ridge parkways.

Ten consultants on reclamation work — engineers, geologists, economists, and appraisers — could be retained by the Secretary of the Interior under the terms of a bill which has been passed by the House and favorably reported in the Senate. Under existing law only five may be retained and appraisers are not included. The consultants could be paid up to $50 per day but no one could receive more than $5,000 in any year.

OBITUARY

EMBERT H. SPRAGUE, head of the civil engineering department at the University of Maine, died at Bangor March 9 at the age of 65. Sprague, who was graduated from Dartmouth in 1900, was engaged for a time in civil engineering and mining in South Africa. He became associate professor at Maine in 1915 and professor in 1920.

GEORGE H. WISE, 61, a retired construction engineer of Edwardsville, Ill., died at Alton, Ill., March 3. Wise, a graduate of Harvard University, went to the St. Louis area about 20 years ago. He worked for a time as construction engineer for the St. Louis Gas & Coke Co.

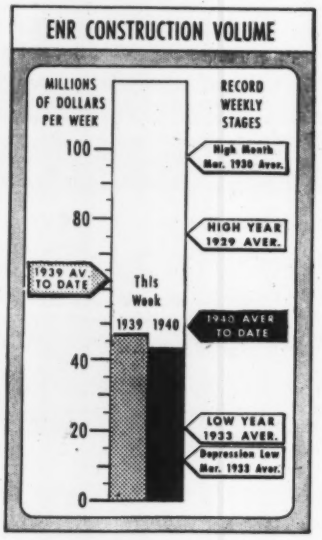
LUTHER S. MUNSON, 64, president of the Munlock Engineering Co., Washington, D. C., died Mar. 6 in Hyattsville, Md. Following his engineering education in California, Munson worked in the District of Columbia during the World War as a civilian supervising the design of various army projects.

Other recent deaths include: W. A. LOGAN, 89, Canadian civil engineer associated with the development of the Trent Valley canal system, Peterborough, Ont.; AUGUST SIEDER, 69, architect and builder, West Palm Beach, Fla.; HUGH BERNARD CASSIDY, 73, construction engineer employed on the construction of the Canadian Pacific Ry. and recently with the Canadian National System, Quebec City, Que.; JOHN J. HIGGISON, retired contractor of Macon, Ga., Mobile, Ala.; CHARLES H. MCCANN, 67, who retired in 1938 after 42 years in the drafting department of the New York Central R.R., Cleveland, Ohio; HOMER L. BARTLETT, 81, engineer and surveyor and graduate of New York University, Freeport, L. I.; GEORGE E. KRUG, 69, architect of Orlando, Fla., Orlando; GEORGE M. C. RICHARDS, 70, superintendent of construction on numerous large buildings in eastern Canada, Toronto; THOMAS O'LEARY, 70, retired contractor, Louisville, Ky.; J. H. SEE, contractor of Worthington, Minn., Worthington; ROMEO E. ALLEN, 87, civil engineer employed for many years in eastern United States, Shrewsbury, Mass.; EVERETT WADE, 54, builder and engineer, Salt Lake City, Utah; G. W. CONNER, 92, former construction engineer for the Mexico Central Ry., El Paso, Tex.; EDWARD HAMILTON, 73, builder, Los Angeles, Calif.; MAITLAND BRERETON, 66, construction engineer for the Phelps Dodge Corp., Phoenix, Ariz.; ALFRED J. BRABAZON, 81, retired civil engineer, Portage du Fort, Que., and PETER LLES, road engineer with the Carrol-Sharp Construction Ltd., Toronto.

CONTRACTS AND CAPITAL

ENGINEERING construction awards for the week total $43,308,000, a 10 per cent increase over last week, but 7 per cent below the volume for the corresponding 1939 week.

The week's new construction brings the total for 1940 to date to $545,521,000, a level 20 per cent below the volume for the 11-week period last year when the rush to get PWA work under contract in the opening weeks of the year swelled the total. Private awards for the period, $185,953,000, are 9.5 per cent higher than a year ago.



Public construction for the week tops the preceding week by 17 per cent, but is 1 per cent lower than in the 1939 week. Private construction is 1 per cent below a week ago, and 16 per cent below a year ago.

In the classified construction groups waterworks, sewerage, bridges, commercial buildings, and streets and roads top their respective volumes for last week. Waterworks, industrial and commercial buildings, and streets and roads exceed their totals of a year ago.

New capital for construction purposes for the week totals $31,902,000, a 283 per cent increase over the total for the 1939 week. The current week's financing is made up of $27,236,000 in USHA loans to 13 cities for low-rent slum-clearance projects, $4,046,000 in state and municipal bonds, $552,000 in corporate security issues, and $68,000 in RFC loans for public improvements.

New construction financing for the year to date, $216,747,000, is 55 per cent below 11-week period last year.

(Weekly Table on page 35.)

ENGINEERING CONSTRUCTION CONTRACTS REPORTED BY ENGINEERING NEWS-RECORD, IN FEBRUARY, 1940

Engineering News-Record *reports projects of the following minimum costs: — water-works, excavation, drainage and irrigation,* $15,000; *other public works,* $25,000; *industrial buildings,* $40,000; *other buildings,* $150,000

Five Weeks — Thousands of Dollars (000 Omitted)

	New England	Middle Atlantic	South	Mid West	West of Mississippi	Far West	United States February 1940	United States Two Months 1940	United States Two Months 1939	Canada
Public Works										
Waterworks	475	826	571	842	1,100	561	**4,375**	10,595	38,702	25
Sewerage	70	3,792	539	3,982	1,064	1,387	**10,834**	19,533	35,637	528
Bridges, public	511	2,476	1,528	2,386	2,913	4,567	**14,381**	22,386	32,281	315
Earthwork and waterways	64	1,607	2,218	6,961	5,010	6,133	**21,993**	36,632	33,786	35
Streets and roads	614	7,951	12,621	21,438	17,359	3,364	**63,347**	110,398	98,251	2,705
Buildings, public	2,647	17,565	9,661	2,674	4,619	2,726	**39,892**	78,386	130,299	1,130
Unclassified, public	562	4,787	4,043	2,926	2,833	1,963	**17,114**	28,701	26,839	1,510
Total public	**4,943**	**39,004**	**31,181**	**41,209**	**34,898**	**20,701**	**171,936**	**306,631**	**395,795**	**6,248**
Federal government (included in above classications)	488	9 888	6,594	1,217	5,312	10,568	**34,067**	55,800	46,613	.....
Private										
Bridges, private	.....	.....	.....	.....	.....	.....	.....	.....	876	.....
Buildings, industrial	563	3,757	15,125	8,285	6,115	19,897	**50,742**	72,279	20,368	1,815
Buildings, commercial	3,151	9,449	5,443	8,415	1,683	7,906	**36,047**	58,631	66,319	810
Unclassified, private	307	2,025	1,696	425	4,475	3,275	**12,203**	25,364	32,178	856
Total private	**4,021**	**15,231**	**22,264**	**17,125**	**12,273**	**28,078**	**98,992**	**156,274**	**119,741**	**3,481**
Total Engineering Construction:										
February, 1940 (5 weeks)	**8,964**	**54,235**	**53,445**	**58,334**	**47,171**	**48,779**	**270,928**	.....	.....	**13,840**
January, 1940 (4 weeks)	5,423	62,086	31,096	26,716	44,170	22,486	**191,977**	.....	.....	4,111
February, 1939 (4 weeks)	8,578	50,620	41,282	41,097	45,804	16,462	**203,843**	.....	.....	5,041
Two Months — 1940	14,387	116,321	84,541	85,050	91,341	71,265	.....	462,905	.....	13,840
Two Months — 1939	32,088	153,873	76,015	91,797	104,630	57,133	.....	.....	515,536	8,910

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

"Tornado" and "Hurricane"

Sir: The Engineers Club of Memphis would like to bring to your attention an unusual coincidental occurrence. On January 11 two committees appointed by the president of the club to nominate officers for the next year met in joint session to select the names by which their tickets would be designated. The names chosen were "Tornado" and "Hurricane", and the names of the candidates were announced at the meeting of the club on Jan. 15.

Your issue of Jan. 18 was received in this office on Jan. 20 while some of the subscribers did not receive their copy until Jan. 22. The cover of this issue showed the two army tanks carrying the names "Tornado" and "Hurricane". The election was held on Jan. 29 and the candidates elected were as follows: President, Joseph H. Miller, Tornado ticket; Vice-President, Robert H. Hoshall, Hurricane ticket; Sec'y-Treas., John J. Ryan, both tickets; Director, Lawrence H. Lanahan, Tornado ticket; Director, James R. Stevenson, Tornado ticket.

You can see that your cover picture was correct in showing the "Tornado" tank ahead of the "Hurricane" tank.

J. W. PUMPHREY,
Associate Engineer
U. S. Engineer Office
Memphis, Tenn.

Three-Point Problem

Sir: Regarding the article, "Three-Point Problem Simplified" (*ENR*, Oct. 12, 1939, p. 488) permit me to point out from plane geometry, "The vertexes of all angles of a given magnitude whose sides pass through two fixed points, lie on a circle that passes through the two fixed points and any one of the vertexes."

Thus as the plane table is rotated the like points of the similar triangles of error will generate three different circles, the intersection of the three being the desired point.

In the solution the writer connected the similar points with straight lines, which will not intersect at a common point, unless the circles are large enough and the arcs concerned short enough to be approximated by straight lines, which could not be called an exact solution.

This also gives geometrical proof that the point can not be located if it lies on the great circle, because the three circles will be concurrent and will not intersect at a point.

DONOVAN SOUTHWORTH
U. S. Bureau of Reclamation,
Connell, Wash.

Seawater and Concrete

Sir: May I comment on what is really a very minor matter in Mr. Stanton's most interesting article in your Feb. 1, 1940, issue, p. 59. He states that the cracking in concrete "might have very serious consequences if the structure is later subjected to the action of sea or alkali waters."

His Fig. 2 shows a view of a well-cracked seawall which the caption tells us is 12 yr. old. Seawater intermittently swashed in and out of the cracks at the base of this wall for most of this period. With changing condition of the beach the wall sometimes stands dry for weeks—again waves smash against it in storms or high tides. The concrete is hard and shows no evidence of special seawater attack. One section of the 12-yr.-old wall is built on top of and is an upward extension of an older concrete wall constructed in 1915. This older wall lacks the cracks of the later work but seawater has similarly surged against it for 24 yr.

This is written then not in excuse or palliation of the cracks, which assuredly would expose the interior of the concrete mass to attack by really corrosive waters, but to call attention to the amount of strictly seawater attack these walls reveal.

Some miles up the coast is another section of these walls, also about 12 yr. old. This wall does not have the cracking of the type described in Mr. Stanton's article but its base has been almost continuously immersed in seawater and waves have almost continuously splashed over its face. The consequences of this exposure are nil. On the other hand salt spray, flung up on the top coping and evaporating there has produced concentrations of seawater of a nature really destructive to the concrete which is somewhat porous and made with aggregate of a not very durable nature. The surfaces of the coping have peeled and scaled in many places and there is much individual pitting.

It is suggested therefore that seawater be recognized and regarded as being as harmful and deleterious in its action on concrete as it really is. After extensive observations the writer would appraise it of about the potency of well agitated fresh water.

An admirable feature of Mr. Stanton's article is the fine recognition he gives to the work of Mr. Meder and his other assistants. Sometimes there is confusion in such matters and the distinction between meum and tuum is lost. In generously giving proper credit to his assistants Mr. Stanton gives only the greater credit to himself.

HOMER M. HADLEY
Regional Structural Engineer
Portland Cement Association
Seattle, Wash.

Tamping Efficiency

Sir: The above picture may be of interest as proof of the efficacy of tamping. During construction, someone walked over the fresh concrete of this sidewalk in Manila. Now, about forty years later, all of the surface has eroded except that under the footprints, which still stand out, clear and distinct, in relief. The walk was constructed shortly after the American occupation of the Philippines.

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Ft. Mills, P. I.

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March 14, 1940

CONSTRUCTION BUSINESS for the first two months of the year is more encouraging than one would expect from the statements of the economic soothsayers. A number of these prophets of good and evil have looked down their noses recently at a contract volume that is twenty per cent below the first two months of 1939, disregarding the fact that that period was abnormally high because of the rush to get PWA contracts let before the deadline. Figures for February engineering construction awards now reveal the highest February since 1929. Private awards in 1940 are 12 per cent above a year ago. These can hardly be considered as other than encouraging signs. Public works are making a poor showing, as was expected, but taken as a whole activity in construction so far is cause for satisfaction.

A National Sewerage Group?

WORKERS in the field of sewage disposal will gather in Trenton, N. J., next week to celebrate the silver anniversary of the New Jersey Sewage Works Association, oldest organization of its kind in America. Although locally sponsored, the occasion is one of country-wide interest since important plans will be revealed for the establishment of a national sewerage association. At present there exists a federation of sewage works associations which has knit together the interests and activities of some 25 local, state and district member groups, rendered distinguished service to the profession, and operated with relatively little financial outlay. What can be gained, therefore, through a "strong national association" is a matter that calls for careful consideration. The trend today in practically all of our national societies is toward decentralization; encouragement of active local groups has been found to best serve the needs of the individual. But, on the other hand, objectives of national interest are often better handled by a central body that can speak for the entire industry. The question of a national sewerage association, therefore, is one which deserves the thoughtful interest of everyone interested in the future of this important division of civil engineering.

Fair Contracts

LAST WEEK'S MIX-UP on bids for constructing the Queens Borough Hall, reported in our news pages, is of more than current interest, for it is part of the long and slow progress toward fair mutuality in construction contracts. Intending bidders on this project found certain contract requirements so difficult to meet that they considered it unsafe to name a price or offer to undertake the work. Even if some had been willing to take a chance it is likely that their bids would have been much higher than under less burdensome contract stipulations. There is enough gamble in the ordinary vicissitudes of any construction job to make a contractor reluctant to take an additional gamble on a clause that may ruin him if weather or labor conditions happen to be unfavorable or the supervisory official is cantankerous. The theory of former days that the owner will get the best job at lowest prices under contract terms that favor the owner and require the contractor to gamble on coming out with a whole skin is known to be fallacious. Though much advance has been made since those days toward writing fair contracts, the spectacle of a group of contractors unanimously concluding that they could not safely bid on an important public contract indicates that we still have some distance to go.

Make Them Reasonable

ONE STEP toward writing workable contracts is to clarify the meaning of terms that in literal interpretation would call for mathematical precision. A well-considered suggestion in this direction was made by John R. Nichols two weeks ago before the American Concrete Institute, in proposing a list of tolerances for concrete building construction. Terms like "true and straight" or "plumb" or "must be located accurately" express ideal objectives that can only be approximated, and it is easy and natural for the owner and the builder to differ about the intended degree of approximation. In many cases the dispute must finally be decided by a judge, at the cost of much expense and bad temper to both parties. The right kind of contract should prevent disputes. An accepted code

of tolerances, when fully discussed and agreed on, is one important device for preventing disputes.

Is Burned Up

BRICK AND STEEL and gypsum do not burn, as everyone knows, but in spite of this one of the huge airplane hangers at North Beach Airport was burned up last week. Within the hangar was a forest of wooden scaffolding erected for installation of sprinkler piping and the like, and accidental ignition of some paint and oil supplies started a conflagration. Disastrous scaffold fires have not been exactly rare in building and bridge construction. Steel and fireproofed wood will reduce a scaffold fire risk, and ready extinguishers and hose lines are also useful. The special conditions under which the North Beach work was being rushed to completion may have made such expedients difficult or impossible to use, but other construction jobs may learn from this case that fire protection is a profitable investment.

No Help on Toll Roads

INTERESTING though it be, the decision of New York's highest state court ordering Westchester County to cease collecting tolls on Hutchinson River Parkway is of little significance so far as the general question of toll highways is concerned. Furthermore, what importance it might have is clouded by the fact that the court divided 4 to 3 on the decision.

The prevailing opinion of the court was that the parkway, although built with county funds, has become, through use, an integral part of the state highway system upon which state law prohibits the collection of tolls. Three justices dissented from this view on legal grounds, and there is a large body of opinion that feels it is wrong on moral grounds. Westchester County virtually bankrupted itself by building expensive parkways, now used as main exit and entrance routes to New York City, only to have similar facilities built in other counties, notably on Long Island, with state funds. Westchester feels that the state should assume part of the cost of its parkways that have become state express routes. Getting no encouragement from the state, the county is seeking to make the user pay for the roads.

The next move, already under way, is to seek legislative approval of toll imposition on county built parkways. Such approval if given would be significant, for it would indicate that New York state, notorious for its diversion of motor vehicle taxes to other than highway purposes, would prefer toll highways to any reduction in this diversion. It would also strengthen the belief in many quarters that license fees and gasoline taxes are not regarded by politicians as special purpose taxes but as a general sales tax.

At present, however, beyond the fact that motorists who paid toll on Hutchinson River Parkway get their money back, the decision roils rather than clarifies the waters in which the toll road problem is submerged.

Cut Housing Costs

VIGOROUS GROWTH of housebuilding activity is forecast for the year by all informed observers of construction trends. The outlook is that for the first time in ten years we will exceed a volume of half a million units and thus come near to keeping pace with current deterioration and decay. So good a prospect justifies the hope that the lowest-income classes will get their share of the new houses, instead of having to live in quarters discarded by others as obsolete.

To date this result has not been obtained. The truly low-cost house, the house that the lowliest steady worker can afford to rent, is still only an ideal although encouraging progress has been made since low-income housing first was attempted. Current cost figures of the U.S.H.A. when compared with those of government housing built four or five years ago show reductions large enough to give promise of further possibilities. Costs have been cut in half. But overall costs of $4,000 per unit are still twice the figure that must be reached before low-cost housing is removed from the realm of philanthropy—a modified poorhouse status.

Significant factors in the accounting are high land costs, elaborate plans and expensive construction. There are possibilities of progress in respect to all three. Fictitious land valuations in areas assigned to low-cost housing can be deflated to the level fixed by the income-producing possibilities of this type of use. Housing plans proportioned to unrealistic social-uplift notions can be brought down to earth. Design and construction can achieve greater economies than have yet been reached.

Experience has proved that no magic innovations in material and construction method need be looked for as a solution of the low-cost housing problem. But steadfast effort to overcome known handicaps can cut costs still further.

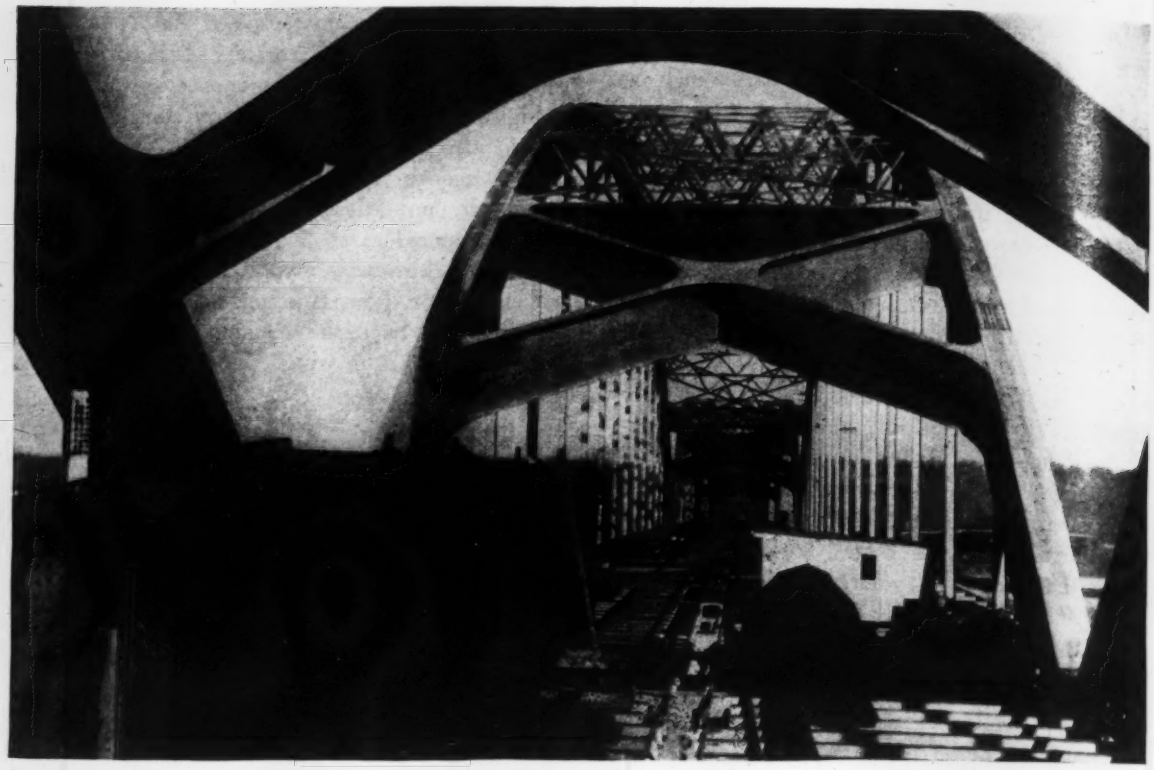


FIG. 1. PLATE GIRDER PORTALS ARE DISTINCTIVE CHARACTERISTIC OF ROCK ISLAND ARCHES.

Tied Arches to Span the Mississippi

***Contents in Brief**—Rock Island, Ill., is building a five-span steel arch bridge, first of its type across the Mississippi River. Financed entirely by private capital, its revenue bonds will be retired by a 10c. toll on vehicles using its 22-ft. roadways. Span lengths are 395 and 540 ft. Ribs are box girders, hangers H-sections, ties are special rolled H-sections weighing 398 lb. per ft., and the shoes are of rocker bar instead of pin type. Erected on steel falsework, the spans were swung with the aid of jacking posts temporarily substituted for the hangers.*

CUTTING THE NATION IN HALF as it does from Canada to the Gulf, the Mississippi River is crossed by many bridges. And the engineers responsible for these numerous crossings have over a long period of years met the varying requirements imposed by foundation, topography and traffic in such a variety of ways that one can travel from St. Paul to New Orleans and see nearly every type of long span bridge that the art has developed. Yet, despite simple trusses, cantilevers, suspension spans and steel and concrete arches, a new type of bridge will soon be added to the list, for on June 11, Rock Island, Ill. will open to traffic its steel tied arch crossing to Davenport, Iowa.

The steel tied arch is not a common type anywhere, let alone across the Mississippi where its relatively short span would normally be ruled out because of the large number of deep piers required for a long crossing. At the Rock Island site, however, a firm foundation of hard clay or shale occurs at a relatively shallow depth (50 ft. or less) into which it seemed possible to drive steel H-piles economically. As finally built, the bridge proved even more economical than contemplated since piledriving for the first pier indicated that the clay was so hard as to permit founding the remaining piers directly on it and dispensing with the piles. These good foundation conditions also satisfied another essential of tied arch construction—ability to use falsework with reasonable ease and economy. The net result is that Rock Island will have a new bridge of simple, pleasing lines which has been economical to build and is distinctive for a Mississippi River crossing.

Heavy traffic will be served

Rock Island is part of the prosperous industrial Tri-City area, which also includes Moline, Ill., and Davenport, Iowa, in a metropolitan unit that is virtually one big city. For many years the federal government bridge to Arsenal Island was the only Mississippi River crossing in the locality; its earliest predecessor,

incidentally, is claimed to have been the first bridge that was ever built across the river. Traffic on the Arsenal Island bridge, a two-lane structure that also carries two street car tracks, reaches rush hour volume per lane as great as any bridge in the country. Several years ago the Bettendorf suspension bridge was built several miles upstream, and it is now a successful toll structure without having greatly relieved Arsenal Island bridge traffic, which still approximates 9 million vehicles annually. Traffic studies, therefore, established that another bridge, connecting directly the business sections of Rock Island and Davenport, could get enough business to support it at a 10 cent toll. Despite the favorable prospects of such a bridge, however, PWA turned down a loan-and-grant request after which the city sold all of the revenue bonds to a private banking syndicate. The financing of the Rock Island bridge, therefore, is as unique as its structural design.

Known as the Galbraith Bridge (the name of the town's mayor) the Rock Island bridge project is 4,447 ft. long between Second Ave. in Rock Island and Second St. in Davenport. Continuous plate girders spans on concrete piers resting on steel H-piles constitute the Davenport approach of 1,075 ft., which is on a 2½-deg. curve and has a maximum grade of 6 per cent. Similar construction, 511 ft. long on tangent, is used on the Rock Island and except that for a long span over the railroad tracks, a cantilever with a suspended section is introduced. The main river crossing consists of 5 tied arch spans of the following lengths from the Rock Island end—395, 540, 540, 395, 395 ft. The bridge deck accommodates two 22-ft. roadways, separated by a 2½-ft. steel center island, while a 5-ft. sidewalk is bracketed out at either side.

From a technical standpoint the bridge contains both design and erection characteristics of interest. Designers would note first the use of a steel H-section for the vital tie member. They would also be impressed by the solid box section rib, the detail of joining the tie to the rib at the pier support and the H-section hangers.

Steel erection men would be interested in the use of adjustable falsework, the handling of 45-ton erection pieces by the deck traveler, the utilization of temporary jacking posts in place of every second or third hanger to adjust the arch rib for closure, and the method of swinging the arch spans free of the falsework. Paving contractors would be interested in the curb and center island detail, which is ideal for the direct support of the finishing machine.

Foundations

Few sites on the Lower or Middle Mississippi have as good foundation conditions as are present at Rock Island. Absent is the deep and

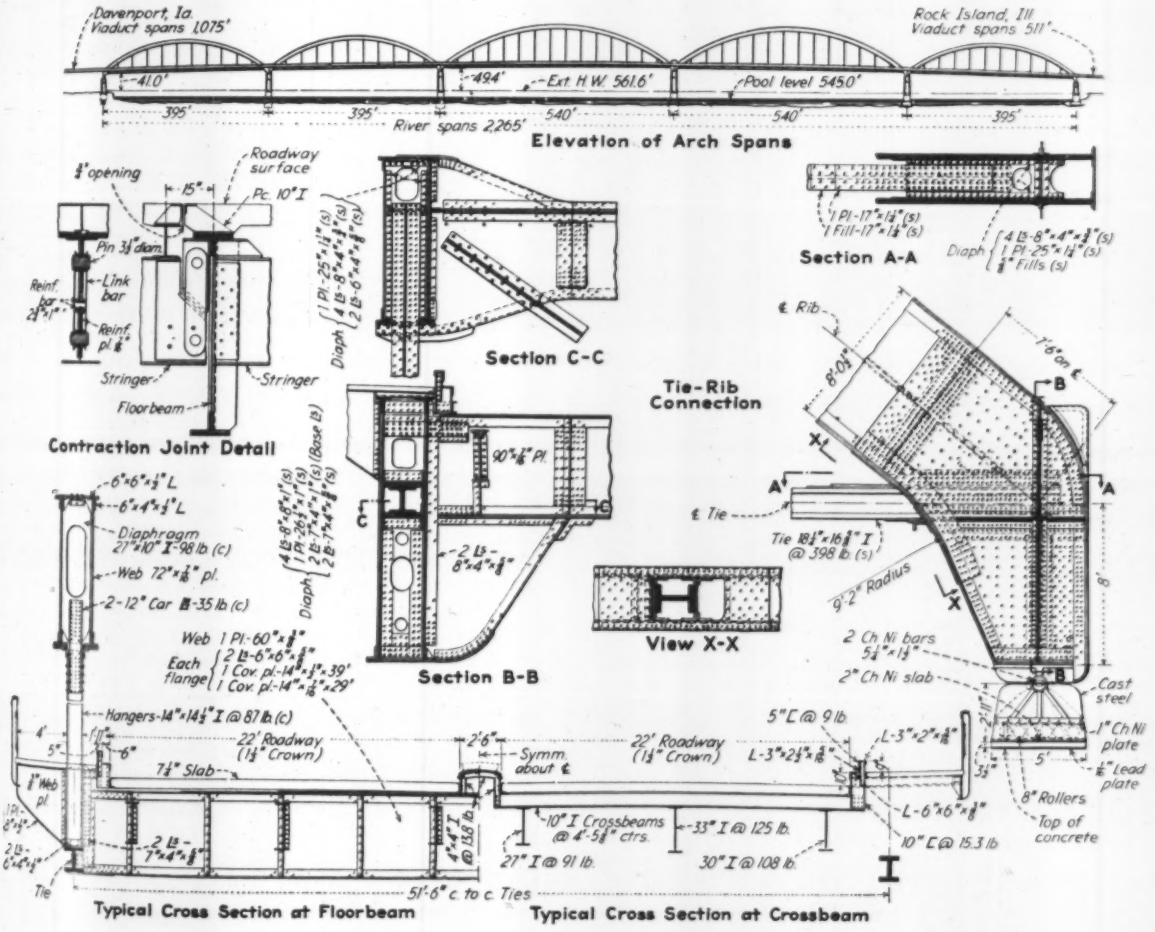


Fig. 2. Structural details of tied arches of Mississippi River bridge at Rock Island. Particularly notable are the box girder rib, the H-section tie and the connection of the two at the piers.

characteristic mud overburden; instead sand and gravel at a depth of 15 or 20 ft. overlies a hard clay shale seldom over 40 ft. below pool level. The two easterly piers for the main spans are founded on rock, a limestone, and as previously stated steel H-piles are used for only one of the four other main piers, the remainder resting directly on the shale. Single-wall sheetpile cofferdams were put down (after the use of a double-wall design on the first pier showed the single wall to be adequate). Excavated to about 20 ft. below river bottom, the cofferdams were sealed by tremie concrete and pumped out, permitting the piers to be built in the dry, using a barge plant equipped with a derrick for handling the concrete buckets.

The concrete approach bents are all on steel piles, with the footings only slightly below ground level to reduce excavation. Although the substructure is comparatively simple, a great deal of study was given the form of the piers and concrete bents to make them pleasing in appearance without any applied ornament.

Superstructure design

In utilizing the 9,000 tons of steel required for the bridge, a guiding objective was to use as many large members as possible and to eliminate small members. The choice of plate girders for the approaches and of the tied arches for the main spans was in keeping with this objective. The use of box girder ribs without lacing bars, the selection of an H-section tie instead of bars or multiple plates, the use of plate girder members for arch portals and the substitution of special rocker bars instead of the usual pins at the shoes are other examples of this attempt at simplicity.

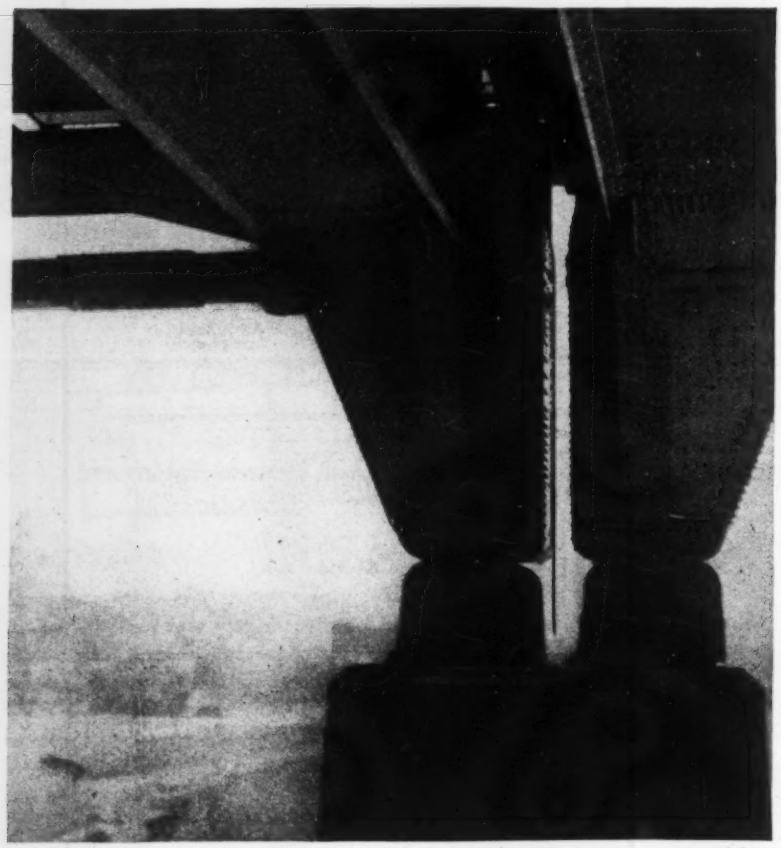


Fig. 3. Rocker bar shoes of adjacent arches; expansion shoe on rollers at left and fixed shoe at right. What appears to be a pin bearing is merely a dust plate over the rocker bars. Splice in the H-section tie is shown at upper left.

Principal interest, of course, centers in the tied arches, details of which are shown in Fig. 2. Of these details several are worth comment.

The rib is of constant section between tie connections, 2[illegible] in. wide and 8 ft. deep. In reducing the section below the tie connections to bring the ribs to bear on the shoes much study was given to its proportions so that it would blend gracefully into the lines of the piers. Diaphragms in the rib, spaced about 5 ft. apart, consist of rectangular frames made up of 6x3½x⅜ in. angles, except at hanger connection points where a 27-in. I-section is used. The H-section hangers (maximum length 94 ft.) are joined to these diaphragms by 12-in. car channels; at the bottom the hangers are connected to the floorbeams by 7x4⅝-in. angles.

Floorbeams consist of 60-in. plate girders and stringers (35.5 ft. long) of I-sections from 27 to 30 in. deep. The 7½-in. bar-truss-reinforced concrete slab is supported on 10-in. I crossbeams at 4-ft. 5⅜-in. centers. Expansion joints at the end of each arch span are of cast steel finger type, and in each span there are four contraction joints detailed as in Fig. 2. Stringers at the contraction joints are attached to the floorbeams by pinned links. A noteworthy detail is the use of a horizontal beam placed at the bottom of each end floorbeam to assist in the distribution of lateral stresses.

The tie is perhaps the most noteworthy member in the bridge, first because of its simplicity, being a single rolled H-section and second because of its size since it weighs 398 lb. per foot, and is 18¼ in. deep and 16⅝ in. wide across its flanges which are nearly 3 in. thick. Since this section is not standard, a special rolling was required for the 5,500 ft. (1,100 tons) required. At splice points, flange thickness was increased over 100 per cent by cover plates so that maximum grips for the two hundred 1¼-in. diameter rivets required at each splice were in the neighborhood of 6¼ in. The tie is supported at each hanger by four rivets. However, at the time of erection only two hangers in the 395-ft. span and three in the 540-ft. span were riveted, the remainder waiting until the bridge was under full dead load. The tie is also supported laterally against each floor beam. As shown in Fig. 2, the tie is entered between the webs of the rib and is connected to these webs by horizontal diaphragms that engage the top and bottom flanges of the tie, which are reinforced and widened at the con-

nection by means of cover plates.

Another detail of interest is the cast steel shoe, in which rocker bars are used instead of pins. These bars, of chrome nickel steel, are 5 x 1¾ in. in section and 3 ft. 4½ in. long. The contact surface of the bar in the upper half of the shoe is plane while that of the bar in the lower half is rounded to a radius of 5 ft. 2½ in. Shoes at one end of each arch are fixed while those at the opposite end are on six 8-in.-diameter rollers moving between chrome nickel steel plates, the lower plate resting on a 3½-in. cast steel bed plate separated from the concrete of the pier by a $\frac{1}{16}$-in. lead plate.

A final detail, also shown in Fig. 2, is the steel stepped curb. Supporting members, consisting of short channel posts, extending 10 in. above the pavement are riveted to each cross-beam and thus occur at about 4½-ft. intervals. A longitudinal angle carried on the top inside corner of this channel serves as the lower curb rail, while a vertical angle riveted to the channel post and extending 9 in. above it carries the upper rail consisting of a channel and an angle. This curb design being open at the roadway except for the channel posts permits water to drain through readily. The lower curb rail has proved ideal as a support for the concrete finishing machine during construction of the roadway slab.

Erection

Fundamentally, erection of a tied arch consists simply of building a falsework support from pier to pier, with bents at every panel point, upon which the floor members can be assembled. The hangers are then used as posts to support the arch rib as it is erected piece by piece.

All tied arch erection follows this pattern but variations may occur in the type of falsework used, in whether each panel is erected complete at once or the entire floor system is laid down before rib erection is commenced, and principally in closure procedure the details of which depend largely on whether tie or rib is closed last.

On the Rock Island bridge, the spans were erected panel by panel and closure was made in the arch rib, tie splices being riveted up as erection progressed. Work began at the Davenport (west) end of the bridge, where the material yard was located, and proceeded eastward.

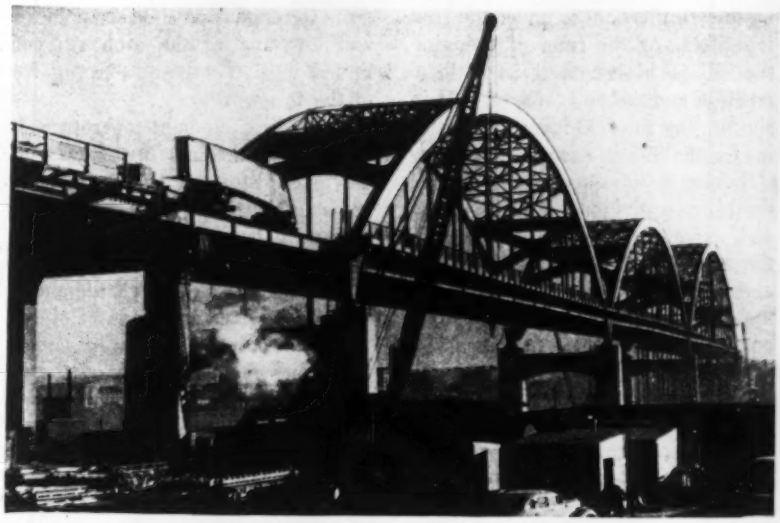


Fig. 4. With three arches complete, first section of rib for fourth arch has just been raised from material yard to a push car on the deck. A gas locomotive will move it out to the erection traveler.

First operation was erection with crawler crane of the first approach girder span next to the river. On this a 65-ton deck traveler with 105-ft. boom was assembled in position to start work on the first arch. Falsework of steel H-piles, with adjustable top sections, was placed by a derrick boat which also erected all floor steel and the arch tie. The traveler then moved out on this completed platform and, always backing away, erected the hangers and the arch ribs in two-panel lengths which were brought out to it on push cars on the deck. Heaviest pieces lifted were the crown sections of the ribs, weighing 47 tons in the long arches and 43 tons in the shorter ones.

The key to the erection procedure was the use of special temporary jacking posts in place of some of the hangers. For the 395-ft. spans of 11 panels, jacking posts were used at points 3 and 5 in each half span; for the 540-ft. spans of 15 panels, they were used at points 3 and 6 in each half span. By means of these posts the arch rib could be raised or lowered to effect connections between the various erection pieces and in the end to adjust the rib for closure and swing the arches free of the falsework. The jacks were also utilized to close the clearance at the last joint in the tie; on one or two spans some horizontal jacking at the end shoe was also required before the last tie splice could be made.

Swinging the spans

As each span is completed it is swung free of its falsework supports

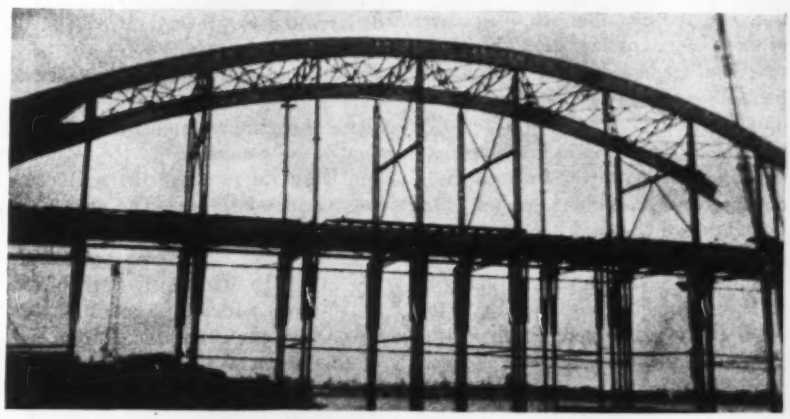


Fig. 5. One of spans approaching completion. Note the jacking posts (with sway bracing between) used temporarily in place of some of the hangers to permit adjustment and closure of the arches. Adjustable steel falsework is also shown.

by lowering the jacks under the jacking posts. At the time of swinging, the rib is higher than its ultimate position and the tie is shorter—2½ in. shorter for the 590-ft. spans and 1½ in. for the 395-ft. spans.

Taking a 395-span as an example, the 1½ in. is divided between the fixed and expansion ends of the arch in the theoretical amounts of 1 1/16 in. and 7/16 in. The anchor bolt holes having been drilled on both piers previous to steel erection, the expansion shoe is bolted down and the rollers locked; the fixed shoe is left free and set 15/16 in. inside (toward the center of the span) from its final position. As the two 100-ton jacks under each jacking post are lowered, the fixed shoe moves outward until the anchor bolts can be dropped in. During this operation the fixed shoe is raised a fraction of an inch on jacks so that it clears the concrete as it moves. With the fixed shoe in place the rollers in the expansion shoe are unlocked and lowering of the arch rib continued until the span is swung free of the falsework.

Depending upon temperature or erection conditions, the fixed shoe may stop short of the anchor bolt holes after all of the allowed-for movement has taken place. This requires that the whole span be shifted toward the fixed end until the anchor bolts of the fixed shoes can be placed. Such a situation is present, of course, only when erection begins at the expansion end of a span, which was necessary with one of the long spans on this bridge since the fixed shoes of the adjacent long spans were placed on one pier for convenience in locating the toll house.

After the closure the jacking posts were taken out one at a time and replaced by the permanent hangers, jacks on the falsework being used to make the hanger connections when necessary. As a final operation the hangers were connected to the tie at those points not previously riveted up and the tie was connected to plates extending out from the bottom of the floorbeams to give lateral support.

Personnel

The Rock Island bridge was designed and its construction is being supervised by Ash-Howard-Needles & Tammen, consulting engineers, Kansas City, Mo., under the direction of R. N. Bergendoff of that firm. Foundation contractor was the McCarthy Improvement Co., Davenport, Ia., and superstructure contractor is the American Bridge Co. Crouse & Saunders, Detroit, have the contract for the concrete deck. William Schmidt is resident engineer for the consultants, with Stephen Collins as assistant. Ned L. Ashton as chief designer and Carl S. Harper as chief draftsman were in charge of design.

Cities Move To Escape Floods

Contents in Brief—Floods and a flood control dam are the reasons why four communities in different parts of the country are moving to new sites.

WHEN THE CITIZENS of Hill, N. H.—a town of 400 population—voted recently to move their community to a new location, they followed the example set by citizens of three other communities who, within recent years, decided to relocate their towns to escape floods or aid in flood control.

Two of the towns—Shawneetown, Ill., and Leavenworth, Ind.—already have moved to higher ground from the sites which, in 1937, were covered by Ohio River floodwaters that almost completely destroyed many of their buildings. Greenville, Mo., is the other town; its present site has been designated as part of a St. Francis river flood-control reservoir system.

The citizens of Hill voted at a town meeting to relocate, and to establish a model village, after the federal government made known its plans for building a flood-control and water conservation dam which will flood the present site.

With the assistance of the New Hampshire state planning and development commission, plans for a model town were drawn up and submitted to Hill's citizens. The plans were studied during several town meetings, and accepted when the residents voted to move their village to the new site.

State and federal agencies assisted in planning the new Shawneetown, about three miles from the old location at the confluence of the Wabash and Ohio rivers along the southeastern border of Illinois. The new town is oval in design, and no part is more than three blocks from the center. The main street is 100 feet wide, and a 30-foot parkway separates the street from the sidewalks. At one end of this street is the Gallatin County courthouse; at the other end, a community building.

Parking areas for the town are behind, instead of in front of, the stores. Houses that were not destroyed by the flood were moved to the new site, and the rest salvaged. Public buildings, for the most part, were built anew. Landowners received deeds to plots at the new town site, which was purchased by the state with $150,000 supplied by the state legislature. The old site will become a state park.

Leavenworth's 450 residents moved to a bluff high above the old site, which had been flooded eleven times since the town was founded. State and federal agencies cooperated in drawing up the town plan and relocating state highways. Work projects Administration officials estimated the cost of streets, sidewalks, water and sewer systems, a town hall, and other construction at a total of $125,000.

Many agencies are cooperating in moving Greenville from its present site to a new one about a mile up the highway. The Missouri state planning board is drawing up the new town plan, with technical assistance provided by consultants supplied by the National Resources Planning Board. Topographic maps of the new site were made by the United States army engineers. The town must be moved by 1941, when the new dam, to hold back waters of the St. Francis River from the Missouri River, is scheduled for completion.

Making a Water Tunnel Entrance 165 Ft. Below Lake Surface

Contents in Brief—Care in advance measurements and in location of powder charges made it possible accurately to control removal of final rock barrier between deep water and a 2,350-ft. tunnel.

A CAREFULLY PLACED dynamite charge recently completed a 2,350-ft. tunnel and at the same time made an opening into Snow Lake, 165 ft. below its surface, through which water will enter the tunnel en route to the new fish hatchery at Leavenworth, Wash. The hatchery is being built because Grand Coulee Dam is too high to permit migratory fish to pass over it. Young fish from this hatchery are to be released in the Columbia River above the dam as well as in the streams which join the Columbia below it.

By driving a tunnel to tap the lake far below its normal water level, a 12,000 acre-ft. storage capacity was made available without the expense of constructing a dam. Preliminary work on the tunnel began about a year ago and the final blast was fired on Oct. 14.

The tunnel was driven from a single heading, starting from the lower portal. The section is 5x7 ft., unlined, and there is a 1 per cent upgrade toward the lake. Prior to development of final plans, the lake bottom near the proposed tunnel inlet was carefully explored by soundings taken in winter through the ice and checked by diamond drill pilot holes driven from the tunnel face as the driving neared completion. With the information thus gained, it was unnecessary to use the large quantity of explosives frequently employed in breaking into a lake below water level. By thus controlling the opening and keeping to a minimum the yardage moved in the final blast, it was possible to excavate in the tunnel near the upper end a depression or catch-basin large enough to retain any rock that might be brought in and still leave an opening adequate for a constant inflow equal to tunnel capacity.

When the final round was drilled and loaded, lead wires were connected and carried out to the tunnel entrance; timbers, ladders and all construction materials were removed from the bore and special closure provisions were made at the lower portal. The outlet works include a 30-in. gate valve to be used in emergencies and a 28-in. valve for normal service. These are located near the tunnel portal where controls were made accessible by a 125-ft. adit. When these valves had been sealed off with concrete and wires to the final charge has been led through a 2-in. pipe embedded in the bulkhead, arrangements were complete.

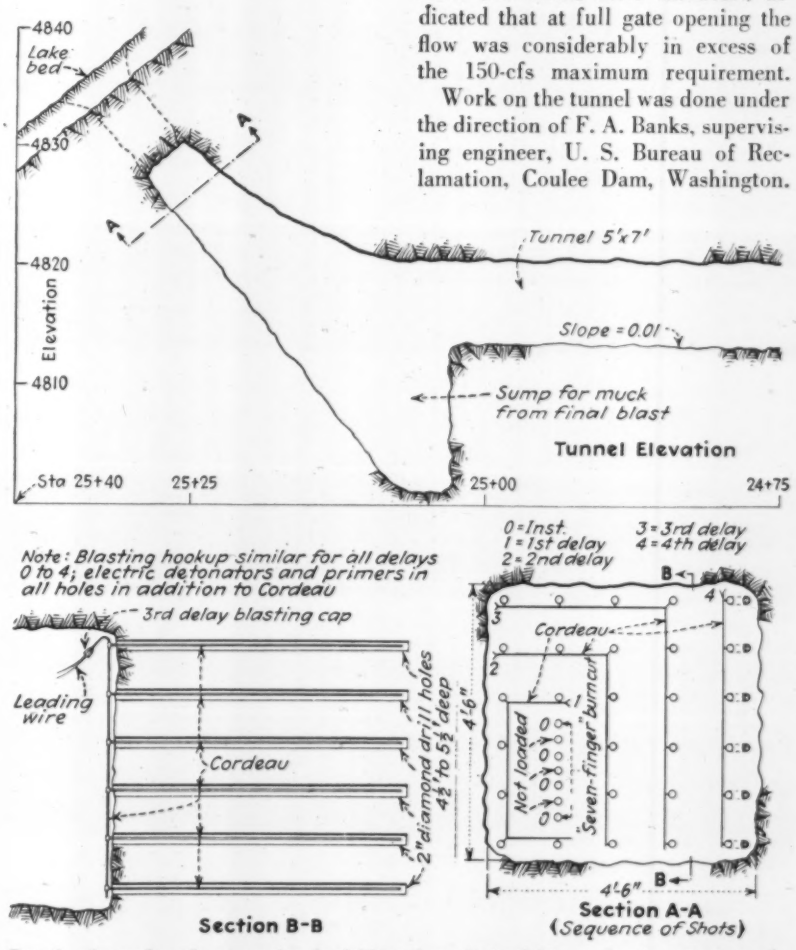
The final powder charge consisted of 60 per cent gelatine powder, electric blasting caps, and a separate detonating system of Cordeau fuse. The Cordeau circuit, intended to assure the firing of all holes in the event of failure of an occasional electric detonator, was fired by an electric blasting cap in the final detonation series.

There was a total of 32 holes in the heading, varying in depth from 4½ to 5½ ft., loaded with 220 lb. of powder.

When the shot was fired, a period of several seconds elapsed before any sound was heard at the tunnel outlet; then a rush of air through the 2-in. pipe was noted. The 2-in. gate valve was thereupon closed and at about one minute after the shot, the gage was found to register 86 lb. per sq. in.

Preliminary tests on the flow of water through the tunnel, conducted some two weeks after the blast, indicated that at full gate opening the flow was considerably in excess of the 150-cfs maximum requirement.

Work on the tunnel was done under the direction of F. A. Banks, supervising engineer, U. S. Bureau of Reclamation, Coulee Dam, Washington.



Details of powder placement for final blast that admitted lake water into the tunnel.

Large Peg Model Reproduces Damsite Borings

A. V. LYNN and ROGER F. RHOADES
Tennessee Valley Authority, Knoxville, Tenn.

***Contents in Brief**—Extensive borings, vertical and angle, over site 8,650 ft. long for Kentucky Dam are represented by wire pegs on a 1:100 model, true in both horizontal and vertical scale. Each peg is painted to represent different materials encountered.*

AS A PART of the foundation exploration work for Kentucky Dam, under construction by the Tennessee Valley Authority near the mouth of the Tennessee River, not far from Paducah, Ky., a peg model of unusual dimensions has been built to indicate the conditions being encountered during the investigations. The model was constructed on a scale of 1: 100, both vertically and horizontally, the use of equivalent vertical and horizontal scales being imperative to avoid distortion of the orientation of the angle holes. The large scale was necessary for clarity, the numerous holes being too closely spaced to admit of clear representation on a smaller model. The damsite being 8,650 ft. long, and the model extending some distance beyond the abutments, the model is 100 ft. long.

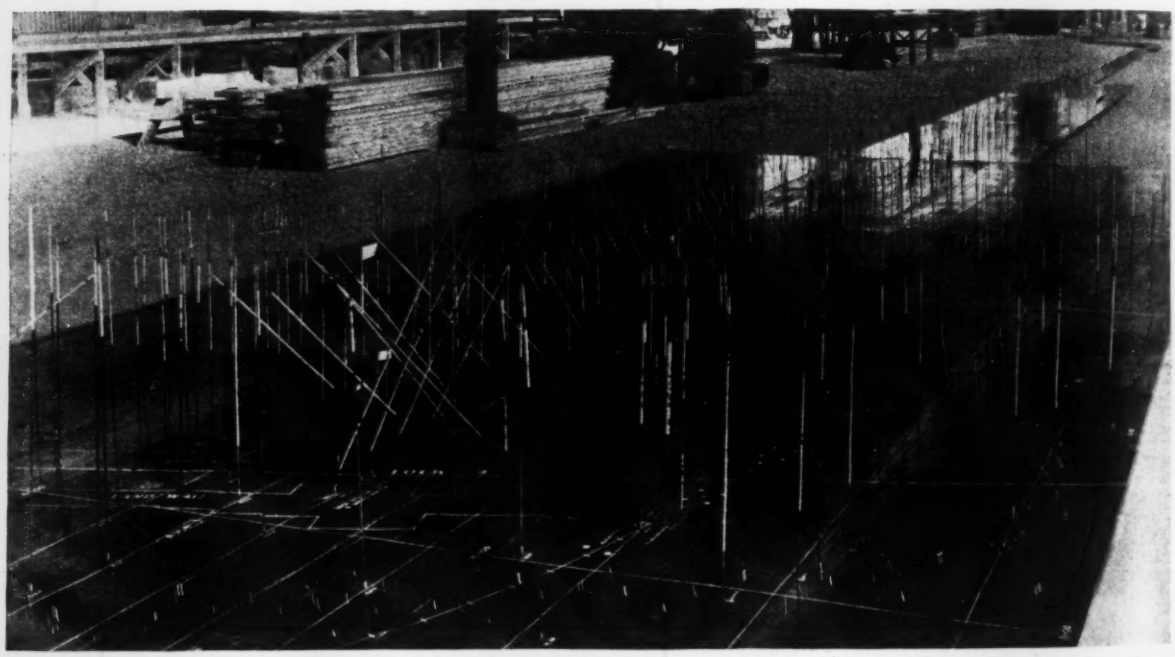
Using a large sectional table for a datum of elevation 100 ft. above sea level, $\frac{3}{16}$-in. steel rods were embedded in the proper position in the table top, bent into the required shape and direction to represent angle holes, and painted to indicate the materials encountered in the particular borings. The bedrock at the site being uniform, it was necessary to use only one color for the rock, which was painted white. Cavities were shown in red, residual chert in green, and river alluvium in yellow. The base of the rods was painted black below the elevations representing the bottom of the holes. Test pits were shown on the model by means of larger wooden sticks painted in the same manner as the steel rods.

The tops of the rods were cut to indicate the surface topography, and the outline of landworks was painted on the table top.

The peg model was a constant source of study by both the engineers and geologists of the field staff, but it also served the more important purpose of enabling visiting engineers to visualize immediately the extent and character of the investigations and the general conditions disclosed. Especially, the model was invaluable at the times of the periodic meetings of the board of consulting engineers and geologists, permitting the consultants to visualize quickly the extent of the progress since previous meetings and serving as a focus for their discussions.

It is particularly noteworthy that this is one of the few models ever made to a true scale in both horizontal and vertical directions. This permitted the placing of the outline of the structure on the actual model which was of great assistance.

G. P. Jessup is project manager on the Kentucky Dam and J. B. Hays is construction engineer. T. B. Parker is chief engineer of the Tennessee Valley Authority, and A. L. Pauls is chief construction engineer.



Model 100 ft. long of Kentucky Dam site upon which every foundation exploration hole is represented by a steel rod painted to show materials and cavities encountered.

When and How to Protest

JOHN W. GASKINS
King & King, Attorneys, Washington, D. C.

***Contents in Brief**—Federal contracts often set a time limit for permissible protest by contractors, and written protests are required in case of discrepancies, changes, altered conditions, delays and disputed clauses. Unless contractors conform precisely they stand a poor chance in court, as shown by the famous Grand Coulee dam decision, quoted herewith.*

CONTRACTORS operating under contracts with the federal government have a vital interest in knowing when and how to protest the orders or directions given to them by government representatives. Such orders may direct the contractors to do certain things which they believe they are not required to do under the contract or may prohibit them from doing things which they feel the contract gives them the right to do. Too frequently, contractors hesitate to protest, fearing that if they do so it may antagonize the owner's representatives and result in intentional or unintentional retaliation. This is an error. Protest is allowed and should be exercised and *according to directions for the right of protest limited.*

Government contracts contain provisions which require protest *in a given number of days.* Frequently the specifications contain further similar requirements. Where the contractor fails strictly to observe these requirements and at a later time asserts claims, he is almost invariably met with a defense of failure to protest within proper time. Whether this defense will prevail frequently depends upon other facts and circumstances in the case, but the defense always presents a serious question which could easily have been avoided by a proper protest made within due time.

When to make protest

The form of government contract now in general use requires that when discrepancies in drawings or specifications exist, notice of the discrepancy must be immediately submitted to the contracting officer. Until the discrepancy is adjusted by the contracting officer, the contract provides that any contractor proceeding shall do so at his own risk and expense. This article when read in connection with a later article in the contract permits an appeal from the decision of the contracting officer to the head of the department. *Thus, affirmative action—first a protest and later an appeal—is required of the contractor for the preservation of his rights.*

If any change order issued is unsatisfactory, the contractor must, under the contract, make his claim for adjustment within ten days from the date the change is ordered, unless the time be extended for proper cause. If the claim for adjustment does not result in satisfactory relief, the contractor may still appeal to the head of the department. By inference it is equally clear that a contractor should vigorously protest the requirement that he perform work without a written change order. He should likewise protest the performance of any work under a change order involving more than $500 unless it be approved in writing by the head of the department or his duly authorized representative. As the requirements that a change order be in writing and that it be approved by the head of the department where it involves more than $500 are both contained in the same article of the contract, which further provides that nothing therein shall excuse the contractor from proceeding with the prosecution of the work so changed, it is manifest that *in these two instances the necessity for protest is very great.*

Under the present form of contract it is incumbent upon a contractor to report immediately to the government the discovery of subsurface or latent conditions materially differing from those shown on the drawings or indicated in the specifications. The contract makes no exception, *even though the contracting officer* or his representative is on the job, and, equally, with the contractor, *knows of the changed conditions.* Adjustments of contract price authorized under the "changed conditions" article are to be made in the same manner as prescribed in connection with change orders, and involve the same obligations on the part of the contractor with respect to protest.

Delays increase the amount of time required to complete the contract and thereby may subject a contractor to possible assessment of liquidated damages under those contracts which contain provision therefor. Also delays operate to increase the contractor's cost of performing the work by subjecting him to additional equipment and supervision cost, job office expense, general office overhead expense and many other forms of increased cost, such as protective winter work. The present form of government contract deals specifically only with the possible contingency that the delay experienced may be of such nature as to justify the assessment of liquidated damages or termination of the contract. *The effect of* such delay *upon the contractor's construction costs,* if that delay is caused by the defendant, *is not specifically mentioned.* It therefore behooves a contractor when subjected to delay because of an act or failure to act on the part of the government to keep in mind the nature of his obligation under the contract.

By the terms of the contract he is obliged within ten days from the beginning of such delay to notify the contracting officer in writing of the causes of delay. The contracting officer is then authorized to ascertain the facts and extent of the delay and the contract provides that his decision shall be final, subject, however, to

an appeal to the head of the department within thirty days. For the full protection of all of his rights to an extension of time which would obviate the necessity for the assessment of liquidated damages, the contractor should go through all these steps. While a total failure to do these things possibly might not preclude the contractor from recovery of the losses which he has sustained because of the delay, his chances are greatly improved by a simple protest which definitely places the government on notice that such delay is adversely affecting the contractor.

Official forms of government contracts contain the provision that all disputes concerning questions of fact shall be decided by the contracting officer, subject to written appeal within thirty days to the head of the department whose decision shall be final. *The courts* uniformly hold that they *cannot accept jurisdiction* of cases involving such disputes *until the contractor has exhausted his administrative remedy* under the contract to have the matter so determined. To invoke these provisions of the contract, it is necessary for a contractor to file protest or take other affirmative steps which will bring the matter to the point where an administrative decision can be rendered. The protest is the initial step which the contractor must take in order to assure himself of the full measure of protection that the law affords him.

Grand Coulee Dam decision

A case in point is the recent decision of the United States Court of Claims in case of the Grand Coulee Dam. In that case a group of contractors entered into a contract with the United States to construct parts of a dam in accordance with certain specifications and supplemental notices which were made a part of the contract. The contract provided that change orders might be issued by the defendant. The first change order that was issued provided in part that instead of constructing the dam in accordance with the drawings and specifications attached to the contract, the contractor should construct the dam and appurtenant works in accordance with revised designs as shown on attached drawings.

The first change order therefore provided for a structure vastly greater in magnitude and widely different in character from that provided in the original contract. The change order provided that compensation for the work should be made in accordance with the provisions of the specifications and of Article 4 of the contract (which related to changed conditions) and limited the time for the submission of claims for adjustment of compensation to sixty days from the date of the receipt of the order unless extended by the contracting officer. Subsequently, the government sent the contractors a document entitled Adjustment of Compensation, which contained the following statement:

> Your claim dated August 23, 1935, has been considered and you have been found to be entitled to the following adjustment of compensation.

The Adjustment of Compensation contained a further statement to be signed by the contractors that:

> Adjustment of the amount of compensation due under the contract and/or in the time required for its performance by reason of the changes above ordered is satisfactory and is hereby accepted.

The contractors signed this statement in December, 1935, and the following January it was approved by the Commissioner of the Bureau of Reclamation and the Acting Secretary of the Interior.

Thereafter, the contractors filed a petition in the United States Court of Claims setting up 31 separate causes of action. The defendant demurred, the legal effect of which was to say that even if the facts stated in the petition were proven by the contractors, they would not constitute a cause of action in view of the provisions of Paragraph 14 of the specifications and Article 15 of the contract (see panel insert). In sustaining the demurrer and dismissing the suit, the court said:

> Each and all of the several counts and claims made in the petition are based upon the action of the contracting officer and it is nowhere alleged in the petition that the plaintiffs filed any written protest against the instructions or decisions of the contracting officer, or made any written appeal therefrom to the head of the department concerned, or did anything in the way of complying with the provisions of the contract with reference to the decisions of the contracting officer.

By this decision the court has clearly indicated that it intends to enforce the provisions of government contracts with respect to protests, and that as a prerequisite to its assuming jurisdiction in the case, the contractor *must have exhausted all of the administrative remedies available to him* under the contract.

Precise action is vital

In the preparation of a protest or other similar affirmative action, a contractor should carefully read the provisions of his contract to make sure that the protest is directed to the correct party in a timely way and as by the contract provided. An instance where a protest was held to be unavailing because directed to the wrong party arose some years ago in a case before the Court of Claims. In that case the decision of the engineer officer by the contract was made final

VITAL CONTRACT CLAUSES

Grand Coulee Dam Decision

Par. 14. If the contractor considers any work demanded of him to be outside the requirements of the contract, or considers any record or ruling of the contracting officer or of the inspectors to be unfair, he shall immediately upon such work being demanded or such record or ruling being made, ask for written instructions or decisions, * and, within ten (10) days after the date of receipt of the written instructions or decision, he shall file a written protest with the contracting officer, stating clearly and in detail the basis of his objections. Except for such protests or objections as are made of record in the manner herein specified and within the time limit stated, the records, ruling, instructions, or decisions of the contracting officer shall be final and conclusive.**

Art. 15. Disputes—All labor issues arising under this contract which cannot be satisfactorily adjusted by the contracting officer shall be submitted to the Board of Labor Review. Except as otherwise specifically provided in this contract, all other disputes concerning questions arising under this contract shall be decided by the contracting officer or his duly authorized representative, subject to written appeal by the contractor within 30 days to the head of the department concerned or his duly authorized representative, whose decision shall be final and conclusive upon the parties thereto as to such questions.

and conclusive upon all matters relating to the work and upon all questions arising out of the specifications. From this decision no appeal was permitted. There was a dispute over the concrete masonry and the manner of laying it. The contractor protested to the inspector and to the local engineer against the way that it was required to place the masonry, but made no protest and took no appeal to the engineer officer. Under the circumstances the court held that the contractor could not recover damages claimed.

How to be safe

To be safe and fully protect his rights, every contractor should in every instance carefully examine his contract and comply with its requirements as to notices and protests. He should not depend upon an oral protest or notice but should put it in writing as soon as the order, direction or delay occurs, and certainly well within the time fixed in the contract. If adopted as a standard practice in all matters, there should be no reason to fear that the government's representatives will resent it.

Thus, with the exercise of only reasonable diligence in the matter of timing, preparing and addressing such protests, contractors will not find themselves beyond the point where they might apply to the courts for assistance in the rectification of wrongs done to them.

Preview of Santee Cooper

From our private correspondence with a staff member on the move.

March 1 — Arrived Charleston, headquarters for the Santee-Cooper power and navigation project in South Carolina. Riding down to the hotel with me was a man with a big roll of blueprints who proved to be F. W. Peters of the McCarthy Improvement Co., one of the contractors.

The Harza Engineering Co., engineers for the South Carolina Public Service Authority, has its office in a large rambling building in the old part of the city, there being no lack of space there. The big drafting room, in contrast to its antique surroundings, is equipped with the latest in fluorescent table lights and modern reproducing equipment. Harza's staff numbers 98.

The Santee-Cooper spreads over a considerable part of the south central section of the state. Briefly, the big muddy Santee River is to be dammed and raised about 30 ft. (by an 8-mile-long earth dike and concrete spillway) to permit diversion of a large part of its flow into a big reservoir over in the basin of the Cooper River, a small stream to the south, where Pinopolis Dam, a rolled fill, will create a head of 75 ft. for power development. Nearly a century and a half ago, a small canal was built along the general line of flow that the water will follow in this project.

It connected Charleston, the chief seaport of the state, with the interior towns on tributaries of the Santee River. That project is to be revived but with one lock having a 75-ft. lift at Pinopolis Dam instead of 13 locks as on the old canal. On our trip over the project we visited one of the old locks. The timber gates are all gone but the wrought iron fittings are still there and the brick masonry is still in remarkable condition.

What traffic or how much will use the new canal is an open question. Probably the chief function of the navigation facilities was to get support for the project from waterway advocates, also to take some of the cost off of power. And as to power, the Authority has high hopes of developing a market, but as yet has produced little concrete evidence that it can.

Some idea of the magnitude of the project can be gained by the fact that 250,000 acres of land had to be surveyed in the two reservoir areas. The titles were found to be in a mess, much of the land having been grants from English kings, none too accurately described originally, and often passed on to slaves by verbal understanding with no recorded transfer.

In the Santee reservoir area is a large amount of marketable timber, some a virgin stand of magnificent cypress that is giving the Authority one of its major headaches. It must get this timber out quickly; yet to cut and sell so much timber in so short a time will disrupt the timber market of the state.—V.T.B.

P. S.—The article on the engineering features of the project will be ready for publication soon.

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Federal Aid Spurs Illinois Sewerage

Notable progress has been made in municipal sewerage and sewage disposal treatment works in Illinois during the past five years. This has been due largely to federal assistance through PWA and WPA, according to *The Digester*, a bulletin of the state department of public health. Four new sewerage systems, including treatment plants, and eight projects for treatment plants only, have been completed with PWA participation, while 34 plants and 32 sewerage systems are under construction. In addition, 17 major projects are in the final stages of development.

About 250 permits for sewer extensions have been issued, and hundreds of miscellaneous projects for repairs, replacements, storm sewers, relief sewers and the smaller class of treatment works have been completed or are under construction. All this has been done with WPA assistance, and it is estimated that 33 per cent of the State's population is served directly or indirectly by these improvements.

It is stated that sewer construction is specially adapted to WPA work on account of the relatively small material cost and the large amount of unskilled labor required. But besides this, the report says: "The excellent quality of workmanship found in the treatment plants is ample testimony that this type of work can also be handled economically under competent supervision."

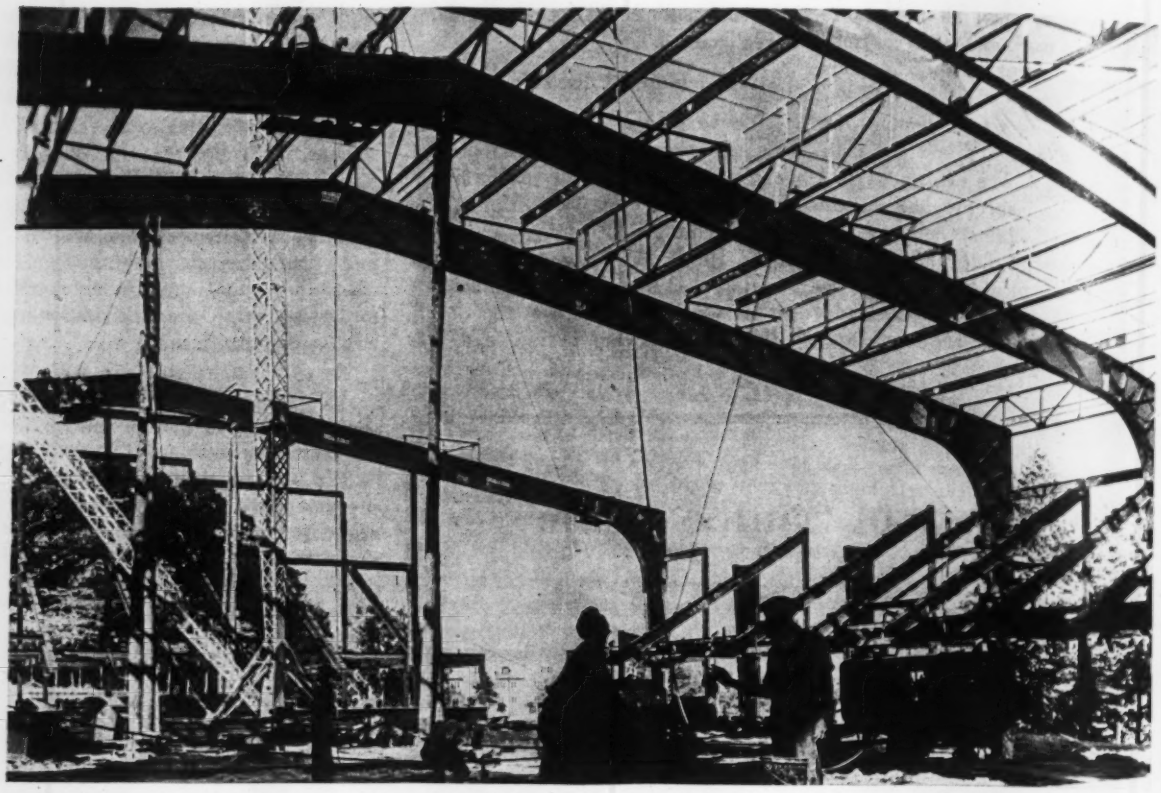


FIG. 1. ERECTING THE 171-FT.-SPAN FRAMES THAT SUPPORT THE ROOF AND MONITORS.

Seats for Nine Thousand Fans

A. C. LEE
W. S. Lee Engineering Corp., President,
Charlotte, N. C.

Contents in Brief—Duke University's new gymnasium unit is a rigid frame structure which provides an unobstructed view of the playing floor for 9,000 people. The balcony, steel frame with concrete seats, accommodates two-thirds of the spectators, and collapsible bleachers care for the rest. Frame consists of steel rigid frame bents of 171-ft. span erected in five pieces with the aid of a single falsework bent. Building is enclosed in native stone. Temperature control in auditorium is by unit heaters and a large-capacity forced ventilation system is provided.

SEATING ACCOMMODATIONS for 9,000 basketball fans are provided in a new addition to the gymnasium at Duke University; although called an addition, it is a complete unit, apart from the older buildings of the university's athletic plant. Providing facilities for indoor sports, the building is also used for community gatherings and concerts.

Outstanding features of the addition include rigid frame column and roof bents, exceptionally good sightline from all seats, and collapsible bleacher units which can be rolled into position to accommodate 3,000 of the 9,000 capacity on short notice. The rigid frame bents make possible a comparatively low roof, with a steep balcony line, which in turn gives the good sightline.

The new gymnasium is laid out with a balcony around all four sides of the building and a continuous concourse underneath the balcony (see section through building). The balcony is divided into 16 sections, each having an exit 3 ft. 6 in. wide leading out to the concourse. The central portion of the building accommodates the large playing floor which has been made of an adequate size to accommodate three full-size basketball courts. Around this area are arranged dressing rooms, reading rooms, lounges and the business offices of the athletic department. In addition, there are two large rooms with earth floor suitable for indoor practice for football, track, baseball and golf. Conforming to the architecture of the other buildings of Duke University, the new gymnasium is of native stone rubble with lime-

stone trim. The building has exterior dimensions of 175 ft. by 262 ft. and a clear play area of 96x183 ft.

Structural steel frame

Nine fixed frames having a span of 170 ft. 11 in. and spaced 26 ft. apart make up the main carrying units of the frame. On these are carried the roof purlins and monitors. Intermediate columns along the walls and a row of interior columns around the playing floor provide the other supports necessary for the concourse and balcony beams.

The structural steel has been designed according to the 1939 Specifications of the American Institute of Steel Construction, using a basic stress of 20,000 lb. per sq.in. The following design loads were used for the design of the structure:

Roof dead load (exclusive of frame)	25 lb. per sq. ft.
Live load on roof	30 lb. per sq. ft.
Weight of the frames	8 lb. per sq. ft.
Total roof load	63 lb. per sq. ft.
Balcony and walkway (dead and live loads)	190 lb. per sq. ft.

The use of fixed frames for a building of this type shows a number of important advantages over other types of construction. It will be noted that an exceptionally good sightline has been obtained by using a steep balcony, but without the necessity of having an excessively high roof. There is a clearance of approximately 8 ft. 6 in. between the top step of the balcony and the under side of the roof. There is also the advantage of unobstructed vision from all seats. The height of the frames at the corners is 37 ft. 6 in. and the roof pitch is 1 on 6.

Fig. 3. New gymnasium unit at Duke University put into use this winter.

The dead load and live load on the roof girders amounts to 1,638 lb. per lin. ft. of girder, which produces a maximum positive moment in the girder near the center of the span of 1,580 thousand ft.-lb., and maximum negative moments at the haunches of 3,200 thousand ft.-lb. The roof portion of the frame consists of a 48-in.-deep plate girder having a $\frac{3}{8}$-in. web plate and four 8x6x$\frac{7}{8}$-in. flange angles. At the crown the bottom chord of the girder is slightly curved and at the haunches the depth is increased to 10 ft. and the flange members built up with cover plates. The columns of the frames are supported on 4$\frac{1}{2}$-in.-diameter pins, and the horizontal thrust amounting to 90,000 lb. is resisted by two 1$\frac{3}{4}$-in. tierods. Roof purlins are 12-in. 16.5-lb. I's, spaced at 6-ft. 8-in. centers and supported laterally by two $\frac{5}{8}$-in. sag rods.

Since the entire roof span together with the supporting columns is designed as a fixed frame, and as transportation requirements limited

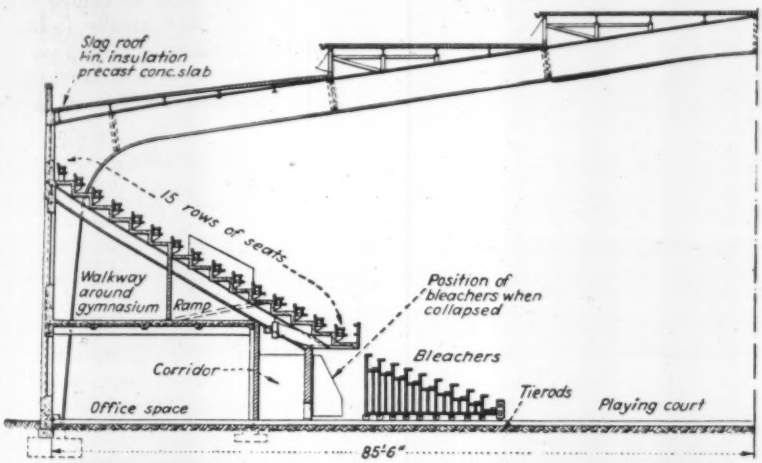


Fig. 2. Half cross-section through the gymnasium. Note bleachers on rollers. When not in use they collapse into a compact assembly that fits under the balcony overhang.

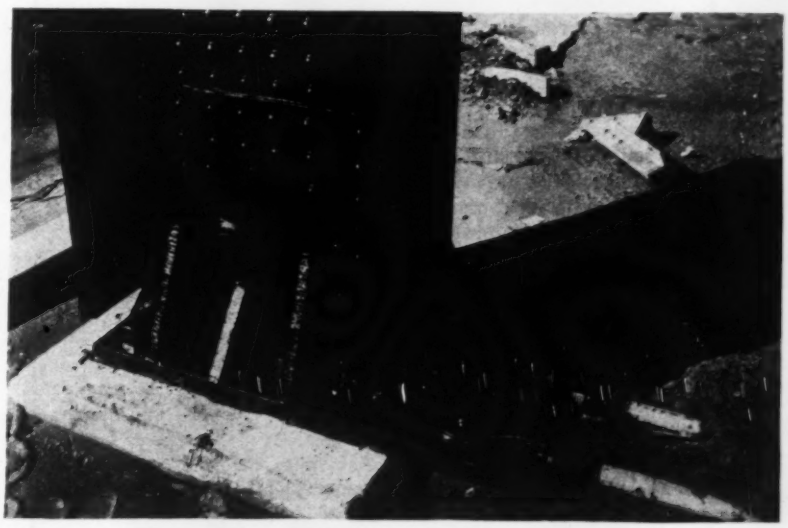


Fig. 4. Detail of a frame base, showing pin, hinged bolster and tierods.

the largest piece which could be handled, it was necessary to provide for considerable field erection. The two columns of each frame, with the haunches, were erected first and held in position with cable guys; then one roof girder was added with the use of a timber to support the outer end; next the crown piece was added, cantilevering it from the girder; and finally the other section of roof girder was added to complete the frame. The timber support was kept in place until the assembled frame was lined up and completely riveted. The weight of one complete frame is 37 tons, and the weight of the heaviest single piece was about 9 tons.

As much as possible of the dead load was added to the roof before final adjustment of the tierods. The tierods were stressed to the amount of the dead-load thrust.

Concrete work

The concrete foundations were designed for a vertical load of 6,000 lb. per sq.ft., and in addition the footings for the main frames were designed to take a part of the horizontal reaction from the roof load. The ground floor, concourse and balcony are of concrete. The 5-in. concourse slab has a steel trowel finish, and it is continuous without expansion joints around the building. The balcony slab consists of risers 5 in. thick and treads 3½ in., the risers being designed as beams to span 13 ft. between steel girders.

The roof is of precast cement tile covered by 1 in. of cork insulation and topped with 5-ply and slag roofing. The four monitors have continuous pivoted sash operated by remote control.

Heating and ventilating

Heating is accomplished by a combination of radiators and unit heaters, the latter located under the balcony and arranged to clear the collapsible bleachers in both open and closed positions. Wall and ceiling radiators are used in the individual offices and around the concourse. High pressure steam is supplied from the central heating plant of the university to the reducing valve in the building.

The heating plan has been based on maintaining a temperature of 65 deg. F. in the main auditorium and 70 deg. F. in the individual offices with an outside temperature of 10 deg. F. Owing to the large number of people who will be in the building at one time good ventilation is essential under all weather conditions. The four rows of motor-operated monitor sash provide for natural ventilation and, in addition, four exhaust fans, each having a capacity of 20,000 cu.ft. per min. and driven by 3-hp electric motors, are suspended from the roof girder at each upper corner of the building.

Lighting

The lighting and other electrical work has been laid out to provide for the varied uses for which the building will be required. The lighting of the entire playing area consists of forty-two 1000-watt lights which are so arranged that one or all of the practice courts, or the main court in the center of the building, may be lighted as required. The lighting has been designed to give a minimum of approximately 20 ft.-candles at the floor level. A special light fixture is provided at the center of the building for the boxing ring. The roof girders and purlins have been painted aluminum to give best light reflection. There has also been included an amplifying system, electrically controlled scoreboard, and complete amplifying and broadcasting facilities.

The base for the playing floor is a 5-in. reinforced concrete slab laid on the ground, in which creosoted wood screeds are anchored. The floor is built up with a creosoted wood sub-floor, one thickness of waterproofing paper and a finish of tongue and groove maple. This floor extends over the entire playing area. Similar floor construction is used in the offices and reading room. The ground floor entrances are finished with terrazzo, and the concourse is of concrete.

The seating has been arranged for maximum comfort. Individual 19-in. seats have been adopted. Around the corners it has been necessary to make use of a few 18-in., 20-in. and 21-in. seats to obtain proper clearances. All seats except the top row are of the riser type, anchored to the concrete by U-bolts set in the risers. This type of chair is entirely clear of the floor and greatly facilitates cleaning. Chairs in the top row are of the floor type and are held in place by cinch anchors set in the concrete.

Direction

The office of Horace Trumbauer, Philadelphia, Pa., were architects for the structure, and the engineering, structural, and mechanical designing was done by the W. S. Lee Engineering Corp., Charlotte, N. C. The entire work on the gymnasium addition was carried out under the writer's personal direction.

Building Maintenance Costs

Costs of maintaining college buildings over a period of years have been compiled at Yale University and are reported by W. W. Randolph, of the Yale University Service Bureaus, New Haven, Conn., in the 1939 annual report of the Connecticut Society of Civil Engineers. Annual costs for internal plus external maintenance over a five-year period (1933-38 in most cases) average from $0.35 to $3.58 per 1,000 cu. ft. of gross volume. In comparison, similar figures collected some years ago from 21 colleges by R. B. Johnson, superintendent of maintenance at Harvard University, showed average maintenance costs of $0.76 to $3.26 per 1,000 cu.ft.

The Yale figures for different types of building are as follows:

Auditoriums	$3.58
Dormitories	2.13
Libraries and museums	1.80
Laboratories	1.70
Academic buildings	1.42
Athletic buildings	0.35

Maintenance cost depends on type of building, construction standards and age, as well as on the available funds. Since during the depression years less money could be obtained for maintenance, the above averages are probably somewhat lower than they would have been in the absence of the depression. They are also affected by the fact that some of the buildings covered are relatively new and therefore show lower maintenance costs than older buildings.

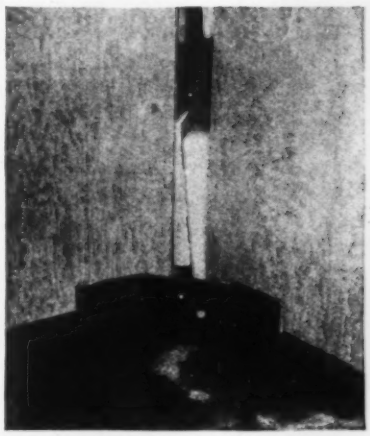
Plywood Form Panels Re-Used 14 Times in Deep Bridge Piers

CONCRETE PIERS for the Narrows Bridge at Tacoma, Wash., are of cellular construction that was built up inside open caissons with the aid of plywood forms. Concrete was poured in 12-ft. lifts. Forms for the interior cells were of light-weight plywood construction that had sufficient rigidity and strength to permit of using the panels repeatedly. A total of 272 panels were employed on the job and although they were used 14 times, neither of the two "spares" was needed.

Panel construction

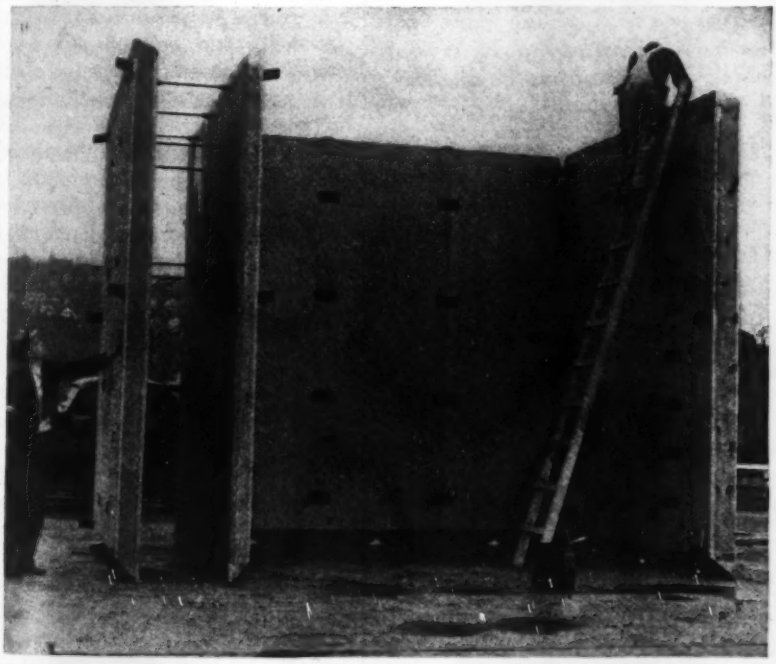
Open cellular spaces within the piers, used during sinking as dredging wells, were formed by an assembly of four prefabricated plywood panels fastened at the edges to form a hollow square. Each panel (mostly 12 x 13 ft. in size) consisted of a framework of 3 x 6's built up at the mill. Although bolts and nails were not used, the framework was made very rigid by use of ring connectors and a special water-resistant casein glue which fastened frame members at joints. With the frame thus rigidly assembled, a waterproof type of plywood, ⅝-in. thick and designed expressly for concrete forms, was glued to both inner and outer faces, thus giving each panel the strength and rigidity available in box-girder construction.

Concrete partitions between the dredging wells were made 2 ft. thick by spacing the plywood forms 2 ft. apart and preventing them from separating under pressure of freshly poured concrete by ⅝-in. tierods, eight to the panel. These tierods had rolled threads engaged by nuts set in metal boxes recessed within the built-up panel to avoid any projection on the smooth panel face where it might be caught by equipment moving up or down inside the dredging well. (These recesses are illustrated below left.



Overlapping steel tieplates, bolted, held adjacent panels together when the wooden wedges were driven home. These connections facilitated removal of form panels after concrete had set.

An important detail was the method of fastening the panels along the edges in such a way as to permit easy collapse and removal. This was accomplished by three tieplates per joint, bolted to the panel frames and overlapping so that they could be bolted together. These steel plates carried the tension developed by driving wedges in the spaces between frame members, set on 45-deg. angles, in adjoining panel edges. After the concrete had set it was only necessary to knock out these wedges, remove the bolts from the overlapping tieplates, and each panel could be broken away from the concrete and lifted up to a new setting 12 ft. above. Through bolts near the tops of the panels served as spreaders until the panels were lifted; then they became anchor bolts for the next set-up.



Plywood forms in trial assembly. Tierods inside the forms (as shown at the left) have their heads recessed in the panels to free the dredging wells of obstruction. When in place in the pier, holes at the right served as a ladder.

Design load

The forms were designed for a load of 650 lb. per sq. ft., which was assumed to be the maximum loading imposed by fresh concrete, in horizontal thrust, under the conditions of pouring that would obtain with the prescribed progress schedule. All plywood surfaces were coated with a synthetic resin sealer as a protection against moisture and to harden the forms against penetration of form oil, which softens wood fibre.

The forms were originated and designed by P. B. Attwell and built by the Speedwall Co., Seattle, using plywood made by the hot plate process.

FIG. 1. PLAIN BEVELED CURB FOR HIGH-CROWNED MEDIAN STRIP IN TOWNS.

Divided Highway Design—III

New Principles of Curb Design

***Contents in Brief**—Divided highways make the curb for the first time a distinctive structural feature of rural roads and have brought a radical change in curb design. Curbs are designed to be surmountable, and the recent development of light-reflecting curbs is adding extra visibility to surmountability. The familiar barrier curb of the city is used only where extreme hazard follows vehicle departure from the roadway.*

THE DIVIDED HIGHWAY has introduced the curb as an essential detail of rural road design and construction. Always before the curb has had no considerable place in practice outside of metropolitan areas. The exception has been curbs for drainage and these have been of the ramp form, hardly more than a lip on the permanent edge, that will carry pavement runoff along the road to over-shoulder spillways instead of allowing it to drain freely at all points onto the shoulders. Even justification of the lip curb for rural roads, as explained later, has been a moot question.

Paradoxically, on divided highways, the curb introduces a traffic hazard to reduce a hazard to traffic. A curb adds a friction surface and therefore a hazard to moving traffic; its justification on divided highways is that it is less a hazard than is the friction of opposing currents of traffic which a curb eliminates. The problem of curb design, then, is to reduce the hazard of the curb itself while preserving its effectiveness as a preventive of unrestricted friction between fast-moving vehicles. The two ways being undertaken are to make the curb safely surmountable and to make it clearly visible. Practice in these respects introduces previously unconsidered factors in curb design.

Curbs to be crossed

The original idea of the curb was to provide an absolute barrier; thus on city streets where curbs originated they were constructed as barriers between vehicular traffic on the roadway and pedestrian traffic on the sidewalk. They served other purposes too but always the idea was that they were not to be surmounted by vehicles and so they were made vertical and high and capable of being crossed only by risking shock and some hazard. This is in general street practice today and also the practice on roads as is noted later, where street-construction conditions prevail or other conditions call for positive barriers.

Contrarily the curb on the divided highway is designed and built to be crossed. In an emergency the curbed median strip can be entered by a wild car, with something of a jounce to be sure but with complete safety. So that this is possible the design principles are self-evident, the curb must be low and its face must be inclined so that cars will easily ride up and over it. Broadly, practice has set 45 deg. as the limit of steepness and 3 to 4 in. as the limit of height. Examples of curbs of this type are shown by Fig. 3. Some of the curbs shown exceed the height limit but their faces generally come within the slant limit. The higher curb is often adopted to retain a high-crowned median strip fill; commonly these high-crowned fills come where built-up road borders call for a narrow median strip as in Fig. 1.

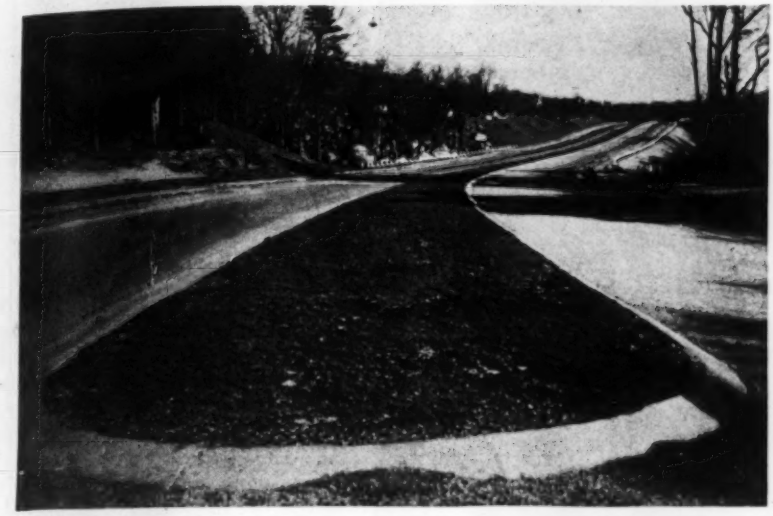


Fig. 2. Slab curb (Type E, Fig. 3) as constructed on a Massachusetts main road with a 16-ft. median strip and two 32-ft. roadways

In respect to forms and dimensions, curbing as built today does not depart greatly from the examples given. In ordinary practice also curbing is confined to the median strip of divided highways; shoulder curbing is rare except for lip curbing, edging and vertical curbs in towns or other places adjacent to sidewalks, turnouts, parking areas, etc. Commonly curbs are of concrete moulded in place but precast concrete slabs, or, in quarrying regions, cutstone slabs, are used. The concrete curb is most common; generally it is the ordinary grey concrete but white-cement surfacing on grey concrete is becoming more favored.

On other than concrete pavements, as brick and bitumen-mixtures, concrete curbs are also general; they may be built up from a concrete base or constructed separately where, as in New England (Fig. 1) high quality bituminous construction eliminates the concrete base. Both brick and bituminous surfaces on concrete commonly have shoulder edgings built up as curbs on the base but only high enough to retain the surfacing. As they do not stand up above the surfacing, these edging strips serve only one function of true curbing which is to delineate the edge of the pavement by contrasting color or structure.

Curbs to be seen

As has been made plain the outstanding design characteristic of modern road curbing is surmountability. To this, recent practice is adding extra visibility. The theory is to increase the reflection of headlight beams back to the driver's eyes by color and a repetition of surface depressions or raised ribs sometimes aided by inset reflector buttons. Examples of the use of reflector buttons are the Merritt Parkway curb in

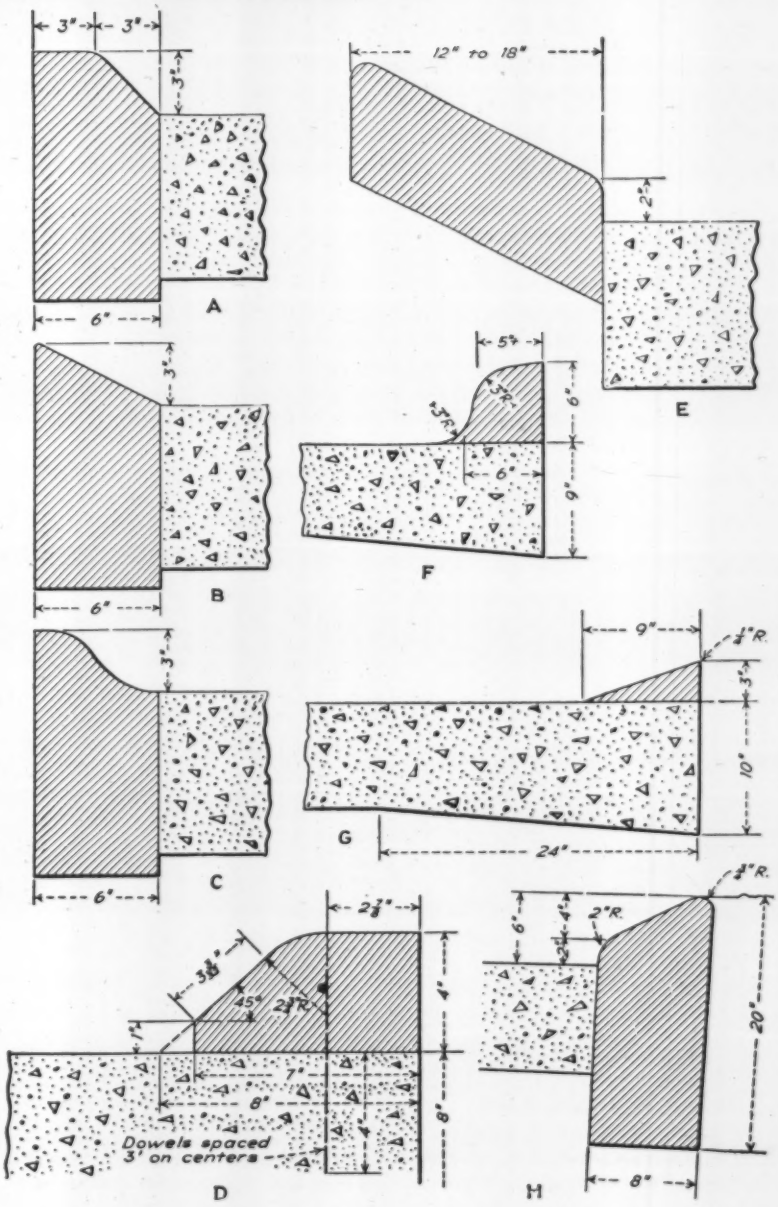


Fig. 3. Current form of low inclined curbs designed to be surmounted safely by a vehicle forced from the roadway: (A) beveled curb, (B) ramp curb, (C) ogee curb, (D) rounded beveled curb, (E) slab curb, (F) integral ogee curb, (G) lip curb and (H) rounded ramp curb.

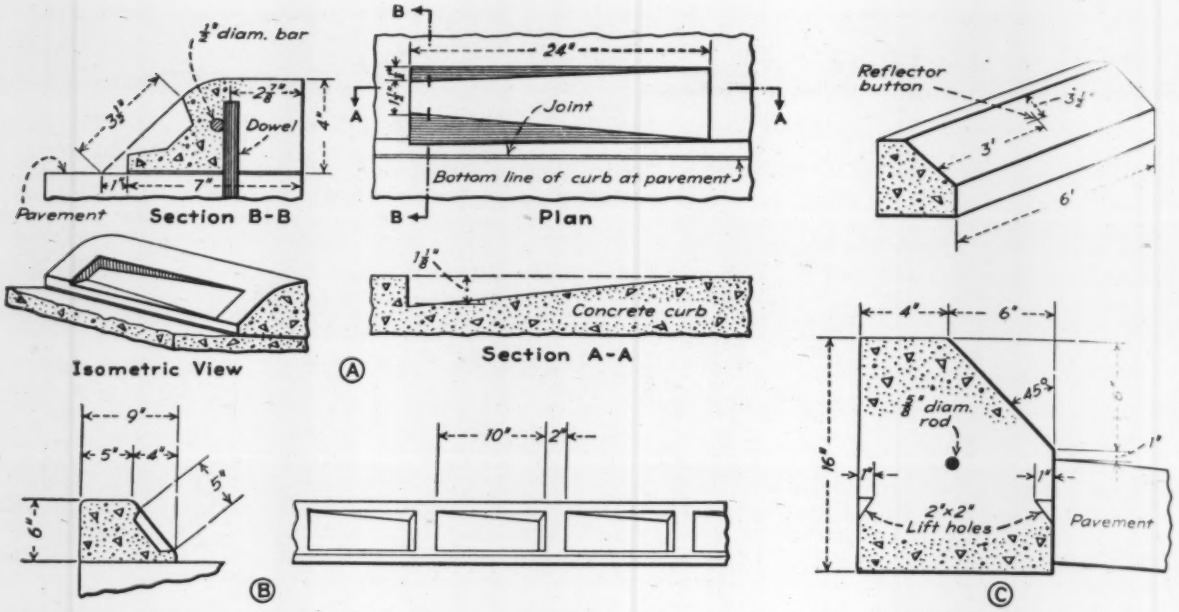


Fig. 4. Types of light-reflecting curbs using reflector buttons as used on (A) the Merritt Parkway, (B) in California and (C) in Rhode Island.

Connecticut, the California curb and recent curb in Rhode Island, all shown in Fig. 4. The most important development of curbing that depends for extra visibility strictly on color and shape of surface is in New Jersey. Forms of this light-reflecting curbing have been designed for surmountable borders for median strips and for vertical shoulder curbs. Curved and straight curb forms have been designed; recent designs are shown by Fig. 5.

Although it is the practice of a single state, the advanced development of the New Jersey curb warrants a somewhat circumstantial account of its design and construction. A statement by H. W. Giffin, New Jersey state highway department, is used as a basis.

Whether the curb is inclined or vertical, the principle of light reflection is the same. Smooth faces normal to the headlight rays and the driver's vision are provided by saw-tooth corrugations, Fig. 10, or depressed panels, Fig. 6, in the face of the curb. With a curb surface of white concrete the depressions and ridges are close enough together to give a continuous band of reflected light such as, for a homely example, is given by a white picket fence viewed at a flat angle. The shape, height and spacing of the surface depressions have been given intensive laboratory and field study to insure greatest visibility under clear, foggy and rainy weather. As produced the moulding is very exact and the texture of the reflecting surface is fine and smooth. This required precision is the principal reason for precast construction as described later.

While admittedly in process of being perfected, the reflecting curb is notably successful. The effectiveness actually increases on rainy nights when, ordinarily, visibility is poorest. Apparently while the film of water flowing over the reflecting surfaces cuts the angle of diffusion to a narrow range it correspondingly increases the intensity of reflection. Design methods, says Mr. Griffin, have "utilized this observable fact with results so satisfactory that in the latest models of precast curb a gleam has been obtained that appears much like

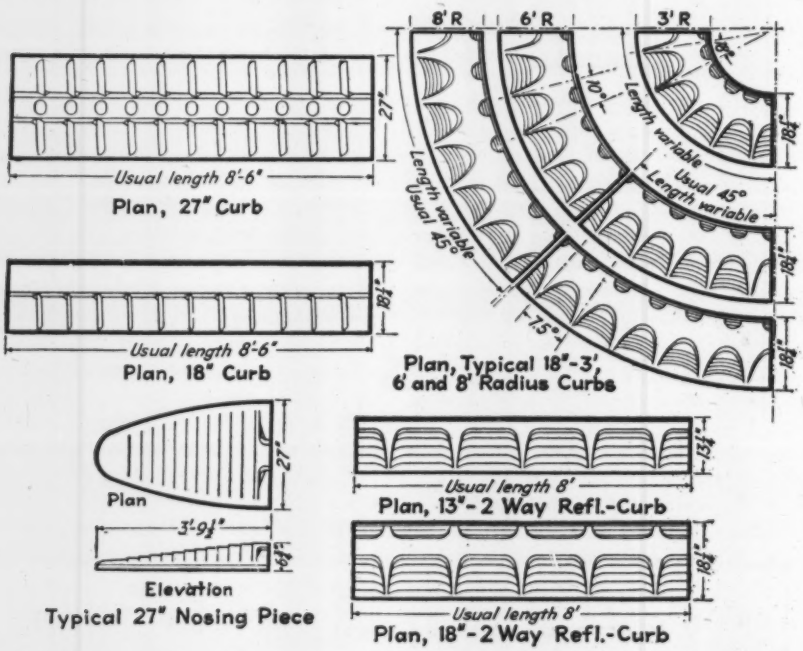


Fig. 5. Light-reflecting curbs used in New Jersey depend on color and shape of face and are precast in all the forms and sizes commonly required for median strips.

a series of reflector buttons set in pairs on the whole length of the curb." The theoretical range of this gleam of light is from 75 to 250 ft. In foggy weather the curb is less effective but it is visible from 50 to 100 ft. farther than other objects.

Light-reflecting curbs are both molded in place and precast. For slant curb precasting produces a smoother and more dense surface and enables the angle of the reflecting faces to be more accurately controlled. The angle is quite critical if the best results are to be secured and on the slant curb that is molded in place this angle has to be produced by scoring the concrete by hand tooling. This costs no more than ordinary finishing but it does not produce the desired surface smoothness and density and accuracy of angle although very good results have been obtained by careful workmanship. With vertical curb, molding in place works somewhat better as the corrugated face is shaped against a properly designed form.

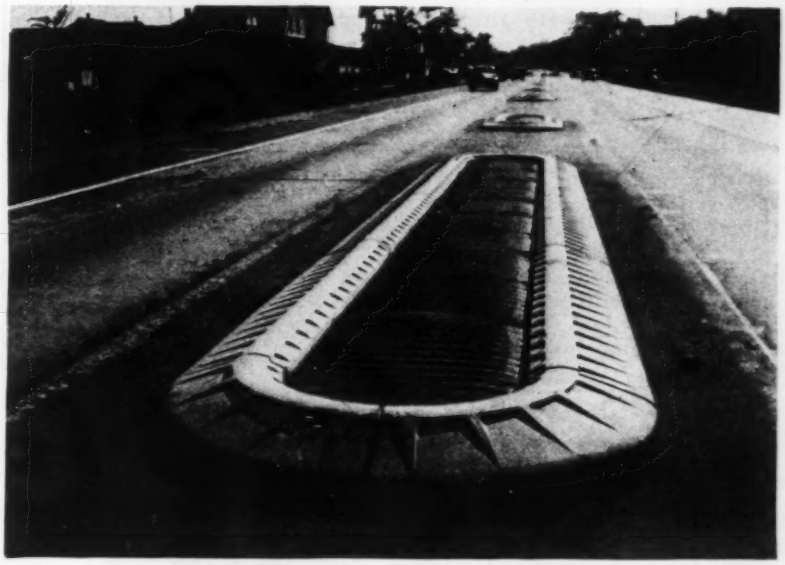


Fig. 6. Light-reflecting curbs laid on old undivided pavement have, with increase in paved width, changed many old New Jersey roads to divided highways.

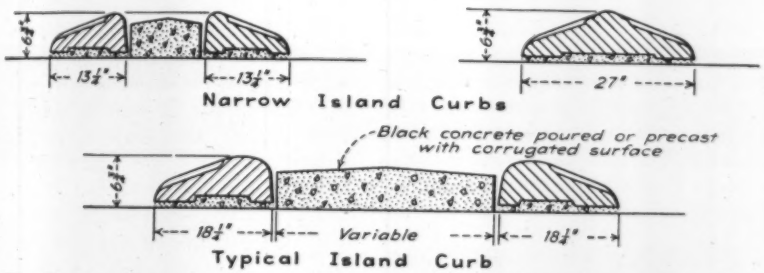


Fig. 7. Superimposed median strips, with light-reflecting curbing, used in New Jersey, offer a variety of arrangements.

Precast curb is generally produced by commercial plants at which special equipment, skilled workmanship and accurate materials and curing control are available beyond the ability of the contractor in the field ordinarily to provide. All curb sections have a white-cement facing; for precast curb it is ½ to 1 in. thick of 1: 5¾ mix, with a ratio of fine to coarse aggregate between 50 to 67 per cent, the fine aggregate being white quartz sand. For curb molded in place the white facing is 2 in. thick of 1: 1¾: 3½ mix. The white facing on all curb is backed by grey concrete.

The precast curb sections are produced in many forms as straight, curved and nose as shown by Fig. 5. This variety of forms has come about more particularly because of the principal form of use of precast slant curb in New Jersey. This is for narrow median strip installed on three and four-lane roads to transform them, with some width added, into divided highways. Fig. 6 shows one of these superimposed median strips. Sometimes the curbs are placed back to back but more often they are separated by a paved space as shown by Fig. 7. A notable feature is the paving between curbs of precast slabs of black concrete with corrugated tops. The corrugated dark surface not only

Fig. 8. Precast sections of light-reflecting curb being placed by hand to form a superimposed median strip on a New Jersey highway.

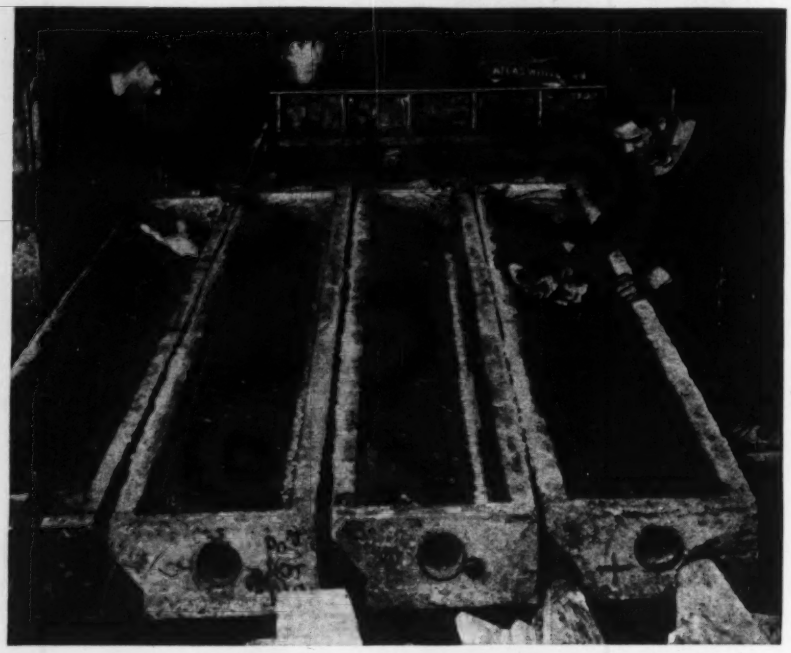


Fig. 9. Concrete moulds are used in shop manufacture of curb to give the fine surface texture and precise profile that are required for light reflection.

affords a marked daylight contrast but at night appears jet black because the corrugations are designed to deflect from the driver's eyes all rays of light from his own or approaching headlights, or from lighting from overhead.

The precast curbs and the black slab fill are bonded to the old pavement by cement. Delivered along the highway by truck the slabs are placed by hand as shown by Fig. 8. In factory molding the curb sections the unusual feature is the use of concrete molds as shown by Fig. 9. The mold is lined with white cement mix and a vibrating mandrel is lowered inside and the white cement is compacted to an evenly thick dense layer firm enough not to slough. Then the ordinary concrete backing is filled into the mold and consolidated by surface vibration. After hardening in the mold the curbs are face patched and smoothed where any small scar may have formed and are then stacked in ventilated piles to cure and gain strength for repeated handling in loading and placing. As stated, the general practice is to let contracts for precasting curbs and the method illustrated is that employed by the Porete Mfg. Co., North Arlington, N. J.

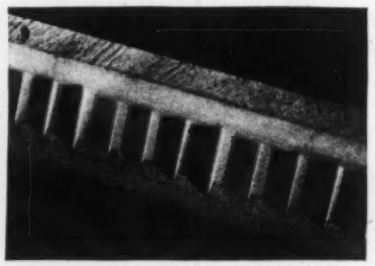


Fig. 10. Barrier curb molded in place with sawtooth vertical face for light reflection, used in New Jersey where a positive crossing restraint is necessary.

Curbs to stop crossing

Light-reflecting vertical curbing is generally molded in place as the corrugations can be shaped accurately by a vertical face form; in New Jersey the curbs are faced with white cement as shown by Fig. 10. Barrier curbs generally have a definite place at parking areas, next to sidewalks and on bridges. Common practice indicates a height of 6 to 8 in. and a vertical or nearly vertical curb face. These curbs are not absolute barriers but overriding them is so forbidding a venture that under ordinary circumstances traffic control is effective. Except on bridges barrier curbs higher than 8 in. are discouraged as being likely to foul running boards, fenders or open doors particularly on high-crowned pavements.

Barrier curbs

The absolute barrier or stop curb is limited to places where the danger of leaving the pavement is very great and sideswiping a curb is a small price to pay for escape from real disaster. Bridges are examples of locations for barrier curbs. Practice indicates a minimum height of 9 in. with a face batter of not over 2 in. Fig. 11-C is such a curb. A similar curb for streets is shown at D. A double curb is shown by Fig. 11-A. With this form the lower curb checks and deflects the car so that the upper curb is rarely surmounted. It is on bridges that invention of barrier curb forms has been most active but all designs have the common purpose of reducing impact damage to vehicles while resisting their departure from the pavement.

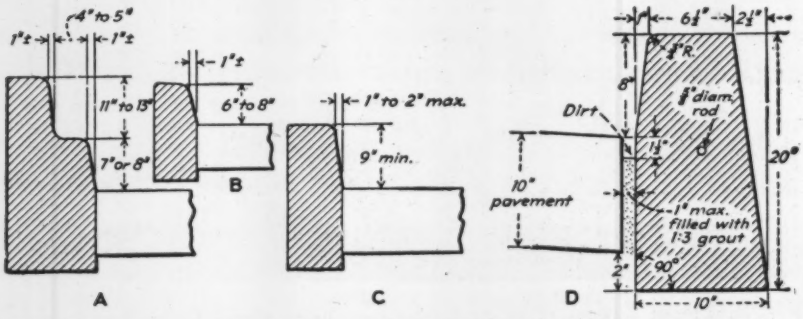


Fig. 11. Common types of barrier curbs that are approved by current practice.

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Lake Michigan Pollution

Some reduction in the sewage pollution of Lake Michigan by a group of Indiana cities is expected to result next fall through the completion of sewage treatment plants at Gary and Hammond. Two other plants are postponed indefinitely. At East Chicago, Ind., a proposed bond issue for the project has been defeated, and at Whiting, Ind., the application for a grant from the PWA for the local project has been rejected.

Progress in Concrete Research

Contents in Brief—Ready-mixed concrete and the question of vibrated concrete vs. tamped concrete received a good share of the attention of those who attended the annual meeting of the American Concrete Institute in Chicago Feb. 27–29. Abstracts of papers on these subjects and others of general interest are presented. A news summary of the convention was published last week (ENR, March 7, 1939, p. 346).

FROST-RESISTANT CONCRETE

ONE OF THE FIRST LESSONS learned from a wide survey of concrete structures is that only a very small percentage of the immense volume of concrete in service has defects of any importance. Even where there has been extensive deterioration, some parts are much more resistant to weathering than others and a great many are in first-class condition. Since in most cases the same materials are used throughout a structure, this variable condition would seem to indicate differences in quality due to variations in processing or finishing.

The majority of the recurring defects coincide with an excessive porosity of the concrete at the points affected, brought about mainly by segregation. Any segregation is objectionable from the standpoint of durability. After segregation the most common cause of dangerous porosity is the use of harsh, unworkable mixes. The most common causes of this are undersanding and poorly graded fine aggregate, especially one lacking in the finer portions. The ill effects of undersanding are common in older concrete structures where the use of arbitrary proportions was the rule. A specification that required a mixture such as 1:2½:5 or 1:2:4, in which the sand was only one-third the total aggregate, would almost always result in an undersanded mix.

Another common source of frost deterioration is defective construction joints, most frequently horizontal joints. A defective construction joint subjects the surrounding concrete to particularly severe exposure because of the fact that the moisture movement through it saturates the adjacent concrete. Thus, even where the concrete mix at the joint is of good quality, deterioration will occur in time and gradually spread. Closely related to joints are cracks. The ordinary shrinkage crack in retaining walls and water impounding structures is seldom as troublesome as the made joint, possibly because it offers more resistance to the passage of moisture. On the other hand, in pavements and roads, cracks probably cause as much or more frost deterioration than do joints. Given a source of moisture, the concrete adjacent to cracks will deteriorate similarly to that along joints.

A great deal of frost deterioration is due to lack of provision for the drainage of water that falls on or is collected by a structure in service. Lack of sufficient slope on horizontal surfaces is particularly objectionable; the location and extent of future scaling can be predicted from the appearance of horizontal surfaces after being wetted.

A frost-resistant structure should have drains wherever needed, so designed that they will not plug. Pockets where moisture can collect should be guarded against. Horizontal surfaces should have sufficient fall. Drains should not be allowed to spill onto concrete surfaces.

Construction joints should receive careful consideration. Those that have to perform as contraction joints should be so designed that when fully closed destructive pressures that might weaken the concrete by overstressing will not be developed, for this makes them more subject to frost attack. Chamfering the edges of joints to avoid pinching is good. Joints to divide the structure into convenient units for construction should be carefully laid out in advance. Horizontal joints should be avoided near the ground line of foundations or near the water line of water impounding structures.

One way of solving the horizontal joint problem is to eliminate them wherever possible. The organization with which the writer is connected has done this since 1930 in all retaining walls, gravity dams, sluiceway piers, etc., up to 70 ft. in height, casting them in one continuous operation; the practice has been a complete success.

A primary requisite for frost resistance concrete is impermeability and low absorption. Most authorities recommend a minimum 28-day compressive strength of 3,000 lb. per sq.in. and a maximum water-cement ratio of 6 to 6½ U.S. gal. per sack. Care should be taken to see that there is plenty of water to carry the coarse aggregate, and any error should be on the side of oversanding. The sand should contain plenty of fines, at least 10 per cent passing the No. 50 sieve, preferably more than 10 per cent.

Workmanship is of the first importance. Every means should be taken to avoid segregation. Chutes, if permitted at all, should be confined to short lengths for final placing. The concrete should be placed initially in that part of the form it is intended finally to occupy; vibrators should not be used to move concrete from one part of the form to another; overworking of vertical faces should be guarded against, and only enough puddling done to keep the large aggregates away from the forms. Overfinishing of horizontal surfaces should be avoided. A float finish is more resistant to frost than one that has been steel-troweled. Overwet mixes should be avoided as increasing the likelihood of segregation and its attendant evils.

Finally, skilled and adequate supervision is among the requirements

for frost resistant concrete. Few good jobs just happen; they will be found to have had expert and detailed supervision.—R. B. YOUNG, *Hydroelectric Power Commission of Ontario, Toronto.*

RAINPROOF WALLS

Leakage tests under spray simulating a heavy driving rain were made on more than 200 wallettes of 4, 8, and 12-in. thickness, 32 in. wide by 48 in. built of concrete units, solid brick masonry, brick facing with concrete black backing, and monolithic concrete. The factors studied included type and grading of aggregate, concrete mixtures and curing conditions, wall thickness, mortar composition, joint treatment, surface texture, surface waterproofing, paint coating, relation between facing and back-up units and excellence of workmanship. The spray corresponded to a rainfall depth of 2½ in. per hr. and was maintained for 24 hr. under a 25-mph wind at a horizontal angle of 45 deg. to the face of the wall. A few tests were made at 56-mph wind velocity.

The following performance ratings summarize the test results:

Excellent—No leaks or back-face dampness.

Concrete masonry with paint coating thoroughly applied with stiff bristle brush to form a continuous film.

Concrete masonry with three-coat cement stucco.

Cast-in-place concrete.

Solid face-brick 8 in. thick, mortar and workmanship excellent.

Face-brick with brick or concrete masonry back-up, 12 in. thick, workmanship excellent.

Good—No leakage and dampening of less than 25 per cent of the back face.

Solid face-brick 8 in. thick, first-class mortar with average workmanship or second-class mortar with excellent workmanship.

Concrete masonry with paint coating superficially crazed.

Fair—Not more than 15 lb. fluid leakage and dampening of not more than 50 per cent.

Solid face-brick 8 in. thick, second-class mortar with average workmanship or third-class mortar with excellent workmanship.

Face-brick 2 in. and concrete masonry back-up 6 in., built with through header courses.

Concrete masonry, spray painted, with minute pinholes.

Solid select common brick 8 in. thick, excellent workmanship.

Face-brick 4 in., common brick or concrete block back-up 8 in., second grade mortar with average workmanship.

Poor—Leakage 15 to 50 lb., or dampening of 50 to 75 per cent.

Cinder block, painted, coating badly crazed.

Select common brick 8 in. thick, third-grade mortar with excellent workmanship.

Very poor—Rapid penetration, leakage over 50 lb. and usually general dampening.

Concrete masonry, unpainted or treated with thin-bodied penetrative waterproofing.

Solid common brick 8 in. thick, average workmanship.

Face-brick 4 in., cinder tile back-up 4 in., average workmanship.

Face brick 2 in., concrete masonry back-up 6 in., built with header block at header courses and with no provision to retard the downward drainage of moisture in the core spaces.—R. E. COPELAND and C. C. CARLSON, *Portland Cement Association, Chicago.*

AGGREGATE SORTING MACHINE

Inspection of crushed stone and gravel obtained for certain tests showed that the crushed stone contained a large number of angular pieces and the gravel contained a large number of flat pieces. Contradictions appeared in early test data. It was therefore decided to separate these materials into types. For this separation the device shown in the accompanying sketch was built. It adequately separated the gravel into rounded and flat, and the stone into cubical and angular pieces.

Several factors in the construction of the separation device influenced the effectiveness of the separation. Most important was the slope of the belt. This slope was kept constant throughout the study. Other factors were the speed at which the belt was running and the material of which it was made.

The performance of the device was satisfactory. Large quantities of aggregates were separated in a short time with an efficiency, as judged by inspection, of 90 per cent.—W. M. DUNAGAN, *Iowa State College, Ames.*

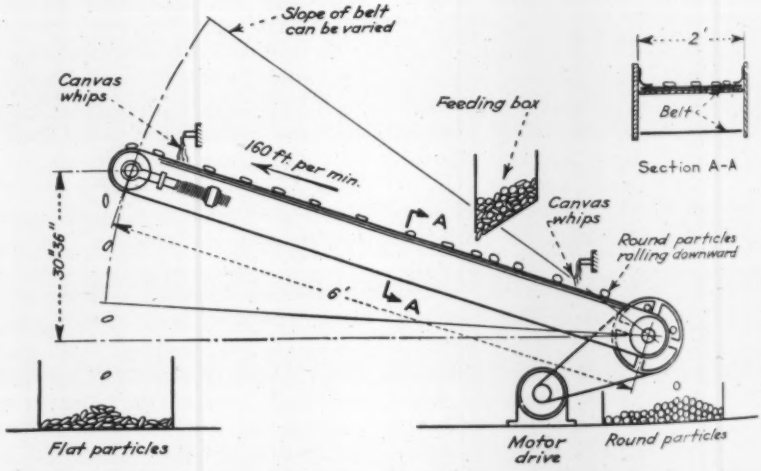
VIBRATED vs. TAMPED CONCRETE

Tests of more than 400 cylinders of different cements and mixes to determine the comparative effect of rodding and vibration lead to the following conclusions, among others:

With the aid of the internal vibrator, it was possible to place satisfactorily no-slump concrete of 1:6:12 mix.

Vibrated concrete showed greater strength than hand rodded, weighed about 4 lb. per cu.ft. more, and usually had more air voids.

For a given water-cement ratio the vibrated mixes had lower leakages than the hand rodded mixes for all but the low heat cements, and used much less cement. The leanest vibrated mix, 1:6:12, had only 2.2 sacks cement per cubic yard.



Dunagan's aggregate sorting device separates flat from rounded gravel and angular from cubical crushed stone.

For a given cement-voids ratio the vibrated mixes usually showed lower leakage and were 200 to 1600 lb. per sq.in. stronger. For a given cement-aggregate ratio the vibrated concrete was 1,000 to 2,500 lb. per sq.in. stronger. For a given cement content per cubic yard of concrete the vibrated mixes were 600 to 3,000 lb. per sq.in. stronger and had lower leakage flows.

There was no definite difference in Poisson's ratio or in expansion due to alternating heating and soaking.

Plastic flow of specimens loaded to 25 per cent of their ultimate compressive strength for two years was 1.3 to 2.0 times as great for hand rodded as for vibrated concrete of the same water-cement ratio. —G. W. WASHA, *Univ. of Wisconsin.*

To investigate the relative effects of tamping and vibration on compressive strength, durability, yield and other properties of concrete in masonry units, a test program was sponsored by the National Concrete Masonry Association in cooperation with the University of Wisconsin and a number of aggregate and equipment producers. The aggregates used included limestone, sand and gravel, cinders, slag and lightweight aggregate. Resistance to 100 cycles of freezing and thawing on 8x8-in. halves of full-size units was an important part of the program. The tamped blocks were made in a heavy-duty power stripper, the vibrated blocks in a jolting machine.

For equivalent yields with the same aggregate, units produced by vibration have higher early strength, absorb slightly less water and in most cases are lighter than tamped units. They also have slightly lower volume change for the same moisture change.

Present specifications of 700 lb. per sq.in. compressive strength at 28 days and maximum absorption of 15 or 16 lb. per cu.ft. of concrete are inadequate to insure masonry units which will be sound and durable under severe exposure.

A minimum compressive strength of 1,000 lb. per sq.in. of gross area is recommended for load bearing units as the simplest and most equitable specification for insuring reasonably satisfactory behavior under severe exposure.—K. F. WENDT, *Univ. of Wisconsin, and* P. M. WOODWORTH, *Portland Cement Assn.*

CONCRETE BUILDING TOLERANCES IN INCHES

Variation from vertical in lines and surfaces of columns, piers and walls	In any story	½
	in 50 ft. or more	1
(Half these amounts for exposed corner columns and other conspicuous lines)		
Variation from level in floors, ceilings, beam soffits—		
	in any 10 ft.	¼
	in any bay	½
	in 40 ft. or more	1
(Half these amounts for exposed exterior lintels, sills and similar conspicuous lines)		
Variation from the straight or from correct position in plan of building lines, or from dimensions, or from positions of columns and walls	in any bay or 20 ft.	½
	in 40 ft. or more	1
Size and location of sleeves, pits, floor openings, location of bolts, inserts and fastenings		½
Location of anchor bolts for structural steel or machinery unless adjustable		¼
Spacing of bolts in a group		¼
Variation in cross-sectional dimensions of columns and beams, thickness of slabs and walls		minus ¼ plus ½
Placement of reinforcement affecting protective covering or effective depth		
(a) in slabs and in members not over 1 ft. wide in the direction of the tolerance		¼
(b) in other members		½

CONCRETE BUILDING TOLERANCES

The above tolerances are tentatively proposed as allowable variations from the "exactly plumb, straight, level and true" of lines, levels and dimensions often demanded by specifications for reinforced concrete buildings. It is suggested that eventually, after discussion, a set of some such tolerances be adopted as standard.

The tolerances given are intended to be maxima for individual cases. Work should be regarded as unsatisfactory if a large proportion of it exceeds tolerances of one-half these amounts.

—JOHN R. NICHOLS, *Boston*

READY-MIXED CONCRETE

During the past ten years the ready-mixed concrete industry has grown from a group of about 100 companies producing about 1,500,000 cu.yd. to almost 700 companies producing about 10,000,000 cu.yd. The first ready-mix operation in Philadelphia was a central mixing plant with a 1-cu.yd. mixer; cement was shoveled by hand from box cars to the boot of a bucket elevator and stored in a wood-stave silo; for the batches, cement was weighed on a platform scale and aggregates were measured by volume; concrete was transported in ordinary dump trucks. From that small beginning, about 19 years ago, the industry has developed to the point where more than two-thirds of the concrete used in Philadelphia is ready-mix.

So far as area of market is concerned, the weighed average haul one way over the years has ranged in Philadelphia from 3.5 to 5.5 miles. Since 1932 the average one-way haul ranged from 4 to 4.5 mi. until two years ago, when development of small house foundation use raised the average haul to 5.5 mi. It is not to be supposed from this record that longer hauls are not feasible or are not made. During 1939 the plants furnished more than 64 distinct classes of concrete.

The market for ready-mixed concrete is limited only by economics, using the word in the broad general sense. Many considerations in addition to tangible out-of-pocket expense items have proved themselves over the years, among them the degree of control over the quality of the concrete, the opportunity for technical control by inspection and record, the standby service which enables the contractor to handle peak yardages which with job-mixed concrete would require excessive plant investment, saving of space in congested areas, and the convenience value to the contractor of transferring part of his estimating, supervision, etc., to another.

These advantages are more apparent in the case of the small job than the large one, since plant investment and operation are relatively high even with simple plants. But ready-mix has also superseded job-mixed concrete on much large work, as bridge construction, where delays for excavation, stripping of forms and steel erection cause lost time for equipment and high job-handling costs.—ALEXANDER FOSTER, JR., H. J. KNOPEL and H. J. WHITTEN, *Warner Co., Philadelphia.*

Introduction of control methods in producing ready-mix gave such

definite improvement in strength and quality of concrete that operators handling job mixing endeavored to improve their practices so as to catch up and remain competitive. The average of concrete production practice in a community was vastly improved. The influence of control extended beyond the concrete operation itself. To produce uniform concrete it is necessary that the aggregates be uniform, especially in grading. The ready-mix operator's demand for uniform grading naturally influenced the aggregate producer to improve his own method, but as he supplies other trade as well the improvement in aggregates was passed on to others, with the result that all local concrete practice benefits.

The efficient ready-mix plant has also contributed specifically to modern methods of controlling water content. The combined result of control measures has been to offer to the ordinary building job the same method of specifying quality of concrete and of assuring such quality as is available to the builder of a major dam.

Ready-mix has been useful to the contractor. Concreting proceeds faster when ready-mix is used than when job mixing is relied upon. Increased speed of placing results in lower labor costs and in a general speeding up of the job. In a recent case, where a contractor had planned to handle concrete on a multi-story building at from 15 to 18 yd. per hour, he stepped up to 30 or 40 yd. per hour by virtue of ready-mix service. Ready-mix production also has simplified the use of warm concrete and thus has become an important agent in enabling building work to proceed through the winter months.

Various other benefits have been offered to the contractor by ready-mix concrete, such as convenience, eliminating noise and dirt, minimizing employment problems, facilitating work on crowded sites, and releasing the contractor's organization to concentrate on placing. More accurate estimating of costs of concrete work as well as economy in designing has followed the introduction of controlled ready-mix. Loss of aggregate on the ground, spoilage of cement and disappearance of cement stacks are eliminated. Because of its effect on control and concrete quality, its influence on other concrete production and its service to the building contractor, ready-mix concrete represents one of the most important forward steps in concreting technique of recent years.—H. F. THOMSON, *General Materials Co., St. Louis.*

Cut-and-Fill Yardages Equal Where Compaction is Effective

COMPARISON OF BULK before excavation and after compaction in fill is the purpose of measurements and observations made by the soils laboratory of the U. S. Bureau of Reclamation in cuts-and-fills on rail and highway relocations at Shasta Dam. Although the studies are not complete, data are now available on typical cases which give some indication of what the final results will be.

In deep cuts on this project a variety of materials were usually encountered ranging from clay above to shale at lower depths. In such cases prediction of volumetric changes when going from cut to fill might not be dependable. Where cuts were relatively shallow and topsoil of a consistent nature was taken out, volumetric change could be predicted more exactly.

Soft rock that required a ripper for excavation is found to occupy greater volume in the fill by reason of the voids that remain after compaction. Just how much these voids are finally decreased depends upon the hardness of the rock and the ability of the hauling and compacting equipment to crush fragments into the voids.

In the accompanying table a summary of data on five sections of railroad and highway embankment is given. The values are based on standard density tests and volume measurements as taken in final cross-section. It is believed that the density in the central portion of the fills is somewhat greater than the values indicated in the table.

The type of compaction listed in the table as "A" was accomplished by normal hauling of earth to the fill in 18 and 25-cu.yd. carrying scrapers drawn by 125-hp. tractors. Travel of scrapers was concentrated largely in the central third of the embankment. Compaction listed as "B" included that described as "A" plus rolling with sheepsfoot rollers drawn by 125-hp. tractors. These rollers were used for an average of eight passes on each 8-in. layer of material deposited by the carrying scrapers. Enough water, with sand or gravel ballast, was used in the rollers to obtain a loading of about 350 lb. per sq.in. on the row of feet parallel to the axis of the roller.

The conclusion was that a balanced line through terrain similar to that on this project and with similar compacting equipment, could be obtained by making a zero shrinkage allowance except where relative rock or topsoil quantities have predictable plus or minus characteristics.

Notes for the foregoing and data in Table I were obtained from the soils laboratory of the U. S. Bureau of Reclamation at Redding, Calif.

TYPICAL SHRINKAGE VALUES IN EMBANKMENTS NEAR SHASTA DAM

Embankment location	Height (feet)	Volume (cu. yd.)	Kind of Material: Per cent rock (+¼ in.)	Kind of Material: Character	Type of compaction	Cu. yd. of fill from 1 cu. yd. in cut	Per cent vol. change (exc. to emb.)
R.R.—A	75	272,000	34.7	Red clay and gravel topsoil over water laid sand, gravel and cobbles	A	1.05	5.0 Swell
R.R.—B	20	245,000	22.4	Same as above but less cobbles	A	.97	3.0 Shrinkage
R.R.—C	8	47,000	32.1	Predominantly red clay, gravel and sand with some cobbles	A	.96	4 Shrinkage
R.R.—D	20	435,000	40.0	Red clay, gravel and sand with soft and hard shale	A	1.04	4.4 Swell
H'y—A	35	354,000	24.1	Red clay and silty topsoil — some decomposed meta-andesite	B	.90	10. + Shrinkage

Pointers on Sewage Disposal Service

PETER A. SMITH
Chairman, Joint Meeting in Essex and Union Counties
East Orange, N. J.

Contents in Brief—This is a story of administration and operating practices based on almost 40 years' experience in providing cooperative sewage disposal facilities for twelve communities in New Jersey. Public relations, personnel policies, business methods and operating procedures are discussed

THESE NOTES are intended to describe the organization, operating policies and business methods applied in the administration of a public enterprise known as the Joint Meeting in Essex and Union Counties. Experiences outlined here may be found useful in the conduct of similar authorities engaged in the business of public service, especially those concerned with sewage disposal.

The Joint Meeting is an agency representing twelve adjoining communities in northern New Jersey for the purpose of providing sewage disposal facilities. It had its origin in 1900, and at the present time operates a trunk sewer system some 54 miles in length, and a treatment plant. The population served is about 300,000, but the capacity of service facilities has been designed to accommodate a one-million population load in this rapidly growing metropolitan area. (Details of the treatment plant are given in *ENR*, Oct. 12, 1939, p. 469.) Although the Joint Meeting includes the entire governing bodies of its member municipalities, to make its work less cumbersome each municipality designates only one of its representatives to serve on the executive committee. These representatives meet twice each month to transact business. The Joint Meeting is subdivided into two groups, dealing respectively with maintenance and construction, for which purpose there exists a joint contract between the Joint Meeting and its twelve members.

Each subdivision has a chairman, a vice-chairman, a secretary and assistant, a treasurer and assistant, a purchasing agent, and a counsel. In addition the maintenance body employs the services of two consulting engineers and a chief engineer who, with a suitable staff, operate a sewage treatment plant and maintain sewerage facilities.

While the prime purpose of the Joint Meeting is to provide for adequate removal and treatment of sewage from the member municipalities in the most economical way, a secondary objective is to cooperate with others in a broad policy of public service concerning sanitation, legislation and kindred matters. The operating staff is urged to assist member municipalities and special equipment is loaned to them. Information is freely exchanged and sought and toward this end the staff is encouraged to visit other sewerage works. We hold memberships in organizations in our field and sincerely try to discharge our responsibilities to these and all others in this work.

In the above, some phases of public relations are touched on. In addition to these efforts we hold meetings that are open to the public and to which the press is invited. And we do not wait to be invited to send representatives to meetings in our territory to explain our work, but constantly seek for opportunities to tell our story. In this connection we arrange for visits to our plant, and try to plan a suitable program for such visits, taking into consideration the make-up of the group. To stimulate interest, signs directing visitors to the plant are set up on the nearby highways, and illumination is provided for night callers.

Our co-workers are frequently reminded of their obligations as public servants and no opportunity is overlooked to encourage cooperation and courtesy. Definite regulations have been drafted to emphasize to the staff what is expected of them. For instance, when men are engaged in work on public streets the foreman advises nearby residents and business people what is being done and gives them an estimate of the time during which they may be inconvenienced. In some cases where access is needed proper crossovers are placed. Police and fire departments

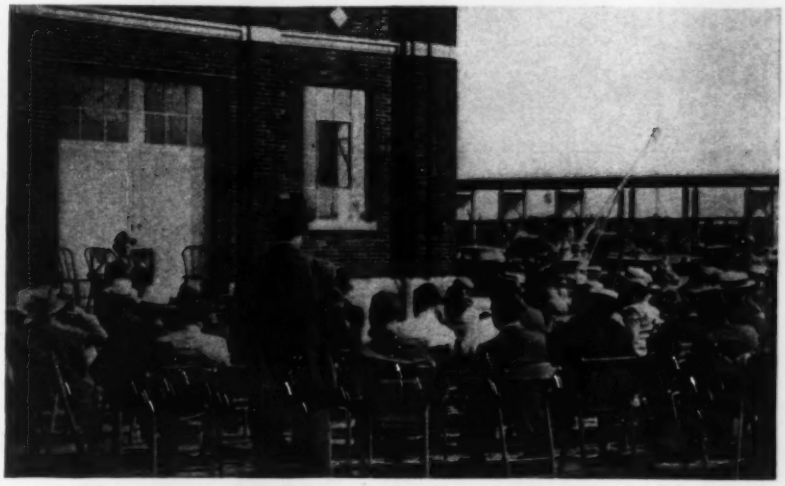


Fig. 1. Public interest in the work of the Joint Meeting is stimulated by plant visits and informal lectures for the visitors.

Fig. 2. Members of the Joint Meeting on a recent inspection of plant facilities. Well-known to readers of this journal are: First row, extreme right, Alexander Potter, engineer-consultant; first row, third from right, E. S. Rankin, secretary; second row, from left to right, Willem Rudolfs, sanitary consultant, L. E. West, chief engineer, and Peter A. Smith, chairman.

and utility companies are informed if the work is extensive or prolonged. Immediate attention is given to complaints and a printed form is used to record them and to state the manner in which they were satisfied.

To achieve efficiency, every effort is made to adopt the use of tried procedures, methods and devices that have been found to be effective in municipal, and professional work.

Office routine includes the maintenance of a schedule of contracts and policy terminations and other recurring items, personnel records, an adequate set of books, a list giving uncompleted items of work made up every three months and a reference system which provides for the dating and numbering of resolutions. The minutes of all meetings are printed and at the end of each year they are indexed and bound in a single volume. The minutes contain engineering and operating reports, legal opinions and other important matters.

Fig. 3. Visual evidence of the policy that a service organization must be equipped to work safely and be ready to meet any emergency. This shows a new man being trained in the use of safety devices for sewer inspection.

Our budget is itemized and monthly comparisons of estimated requirements and actual expenditures are made. Surplus cash, earned by economies, is invested in certificates of deposit earning interest. This surplus is held in the event of an emergency because under normal procedure it takes several months to secure funds from the member municipalities. All bills are paid two weeks after receipt of materials or services and, if possible, discounts are taken. Materials purchased are subject to careful inspection and test, and for all major items the services of an outside testing laboratory are used. Of special interest in connection with our economy measures is the use of a night rider and a limitator to reduce electric power demand charges. The latter device maintains a predetermined peak load and has brought about substantial reductions in power costs.

Members of the operating staff have been selected solely on the basis of their qualifications, and every opportunity is afforded them to increase their usefulness through attendance at courses and technical conventions. Conferences for the exchange of ideas are regularly held, and a pro-

gram of research is underway. At vacation time, opportunities are given to assistants to direct work; incidentally all employees, including laborers, receive vacations with pay.

Firmly believing in competent counsel and informed opinion, the Joint Meeting employs the services of two consultants. They are Alexander Potter, who has been associated with the organization since its establishment almost forty years ago, and who designed and supervised construction of the treatment works, and Willem Rudolfs, chief of the division of water and sewage research at Rutgers University. Chief Engineer Leslie E. West makes monthly reports and recommendations, among which are included special studies on the effect of air conditioning on sewage plant safety, explosion hazards, and sludge fertilizer production. The American Centrifugal Corp. operates an experimental plant at our site where tests are being made in connection with sludge dewatering.

Emergency service measures

Since the Joint Meeting is a service organization covering a wide area, special measures have been taken to insure service particularly in cases of emergency. All employees, therefore, are listed in a directory that gives addresses and telephone numbers. Regulations and instructions covering emergencies, in addition to regular work, have been printed and each employee has a copy. When trucks are put away for the night they must be filled with fuel and otherwise ready to go. Each truck carries a list of service stations which are open all night, and where extra supplies or communication facilities may be had; in addition, a list of doctors, hospitals, police and fire officials is carried, along with complete plans of the sewer system on linen, as well as duplicate blueprints. And to complete the emergency safeguards, arrangements have been made to use the all-night service departments of the city of Newark.

The trucks carry complete service equipment, and are specially provided with first-aid devices (*ENR*, March 16, 1939, p. 398). Of unusual interest is the truck radio receiving apparatus by means of which contact can be established with the service units working on the 54-mile length of the trunk sewer system. An essential piece of equipment is a gas-driven generator, which provides light and power on field jobs.

These notes on the administration of the Joint Meeting are a brief outline of some of the more important practices. Should any reader desire more detailed information the writer will welcome inquiries, and furthermore extends a cordial invitation to visit the treatment plant and staff headquarters in Elizabeth, N. J.

Intermunicipal relations, such as those promulgated by the Joint Meeting agreement of twelve communities to cooperate in sewage disposal, lead to improved service at low cost. For example, the village of South Orange with a population of 16,000 will dispose of its sewage this year at an estimated cost of $7,000. It is almost impossible to point to any other arrangement, except through a cooperative venture such as the Joint Meeting, where such low-cost service could be achieved.

Cost Data on Clay Sewers

MORGAN W. HAYES AND I. W. MENDELSOHN

Formerly Senior Engineers
Public Works Administration, Washington, D. C.

Contents in Brief—Unit cost figures in sewer installations ranging in size from 6 to 24 in. are summarized for twenty-four PWA projects in New York State.

FOR THE PURPOSE of obtaining cost data on recent PWA sewerage projects, an analysis was made of a number of jobs in New York state, all but one of which were let for con-

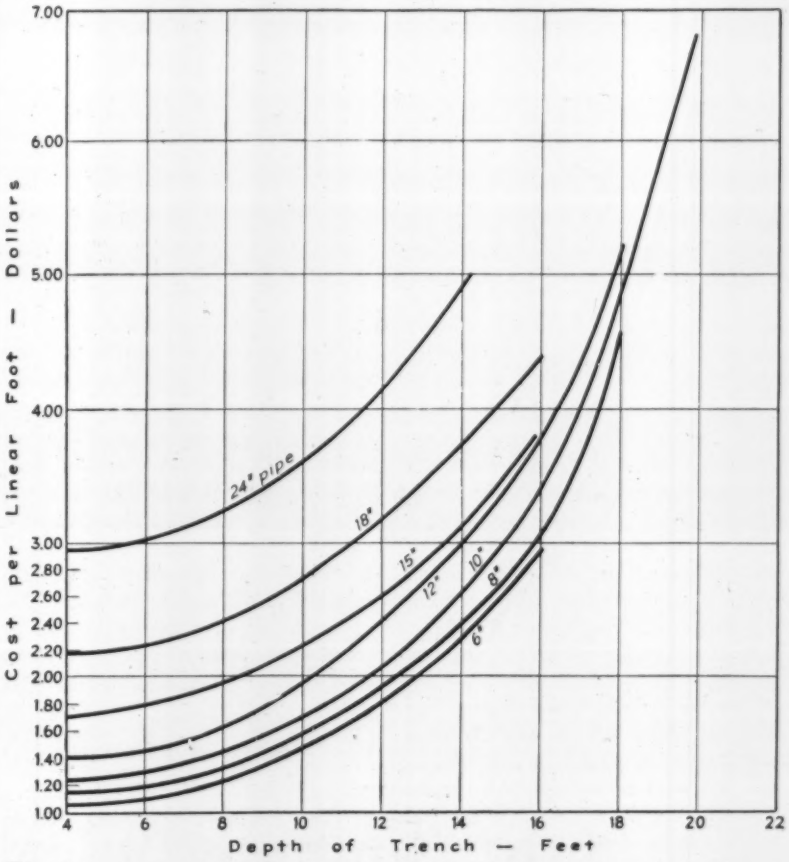


Fig. 1. Unit cost of vitrified tile sewers varying in size from 6 to 24 in. and laid at different depths.

TABLE I—UNIT COST DATA ON TYPICAL PWA SEWER PIPE INSTALLATIONS IN NEW YORK STATE

These unit costs on clay sewer pipe installations made under PWA supervision include the cost of furnishing pipe, as well as the excavation, laying and backfilling charges.

Location	6 in. Pipe					8 in. Pipe						10 in. Pipe						12 in. Pipe						15 in. Pipe						18 in. Pipe					
	Depth of Trench																																		
	6'	8'	10'	12'	14'	16'	6'	8'	10'	12'	14'	16'	18'	6'	8'	10'	12'	14'	16'	18'	6'	8'	10'	12'	14'	16'	18'	6'	8'	10'	12'	14'	16'	18'	8'	10'	12'	14'	16'	18'
Schuylerville							1.59	1.72	1.79	1.84	1.88	1.98		1.62	1.72	1.78	1.88	1.98	2.08	2.46							3.70					4.20					5.50
Watervliet									1.70	1.90	2.30	2.50	2.90			1.40	1.80	2.50	2.80	3.20				2.00							3.50	4.00				4.00	4.50	
Hempstead								1.20	1.20	1.60	2.50																										
Peru	1.40	1.40	1.80	1.90	1.90	1.90	1.50	1.50	1.90	2.00	2.00	2.00	2.00	1.70	1.70	2.10	2.20	2.30	2.20																		
Carmel		1.10																																			
Wallkill		.85	.90	1.08	2.30	3.25	4.40	.95	1.00	1.18	2.40	3.35	4.50	6.50	1.10	1.15	1.33	2.55	3.50	4.65	6.65	1.25	1.30	1.48	2.70	3.65	4.80	6.80			2.25	2.25	2.25	2.25						
South Fallsburg								1.00	1.00	1.00	1.65	1.65	1.65		1.15	1.45	1.45	2.00	2.00	2.00		1.30	1.60	1.60	2.00	2.00	2.00												
Bethlehem								1.00	1.20	1.50	2.00	3.00	4.00		1.20	1.40	1.70	2.20	3.00	4.00	5.00	1.40	1.60	2.00	2.50	3.00	4.00											
Hempstead								1.08	1.08	1.53	2.00	2.33	2.33		1.69	1.69	1.69	2.16					2.30	2.30	2.30	2.63	2.63				3.50	3.50	3.50					
Manchester		1.40						1.00	1.15	1.50	1.85	5.00	6.00		1.50	1.35	2.00	2.30	3.40	6.00		1.60	1.60	2.00	2.75	7.00											
Shortsville								1.00	1.15	1.50	1.75	2.50	3.40	5.00	1.20	1.35	1.75	2.30	3.00	3.75	5.00	1.40	1.60	2.00	2.75	3.50	5.00											
Hudson Falls									1.20							1.40							1.45							1.70								
Tarrytown								1.30	1.47	1.50	2.00	2.50	3.00		1.25	1.50	1.75	2.00	2.50	3.00		1.50	1.75		1.75	2.25	2.75	3.25	4.00		1.75	2.00	2.10	2.50	2.75	4.25				
Chatham		1.00	1.40	1.65	2.40	3.40		1.10	1.50	1.75	2.50	3.50											1.50	1.75	2.25												
Cortland								1.30	1.47	1.50	2.00				1.25	1.50	1.75	2.00				1.50	2.00	2.00	2.00	4.00												
Stillwater								1.00	1.00	1.00	1.50	4.00			1.25	1.50	1.50	2.00	4.00			1.40	1.60	2.00						1.75	2.25	2.25	2.50	3.00					
Youngstown								.90	1.00						1.25	1.50	1.50	2.00	2.50																		
Elmira																																					
Livonia								.80	.80	.85	.90	1.50	2.00	3.50	1.25	1.00	1.00	1.20	3.00	4.00	5.00	1.25	1.50	3.00	4.00								4.00	5.00					
Rockville Center								1.00	1.25	1.50	1.75	2.25				1.50	1.75	2.50	3.00						2.50	2.75	3.50											
Yonkers																							1.55	1.77	1.92				2.21	2.42	2.62							
Yonkers																							1.36	1.54	1.66													
Yonkers																							1.45	1.67	1.82				2.21	2.42	2.62				2.56	2.79	3.00	
Yonkers																							1.68	1.96	2.15				2.01	2.27	2.52							

struction in the latter part of 1938. This group of projects was chosen because of its location in a large industrial state, typical of the New England and Middle Atlantic regions, where freight rates, wage rates and material prices are comparable. A summary of actual bid prices on twenty-four vitrified clay sewer pipe installations is given in Table I, and a graphic presentation of the data is shown in Fig. 1. The pipe sizes range from 6 to 24 in. and the depth of trench varies from 6 to 18 ft. The unit costs that have been summarized include the cost of furnishing the pipe as well as the excavation, laying and backfilling charges. Labor rates typical of these projects are given in Table II.

Pipe sizes

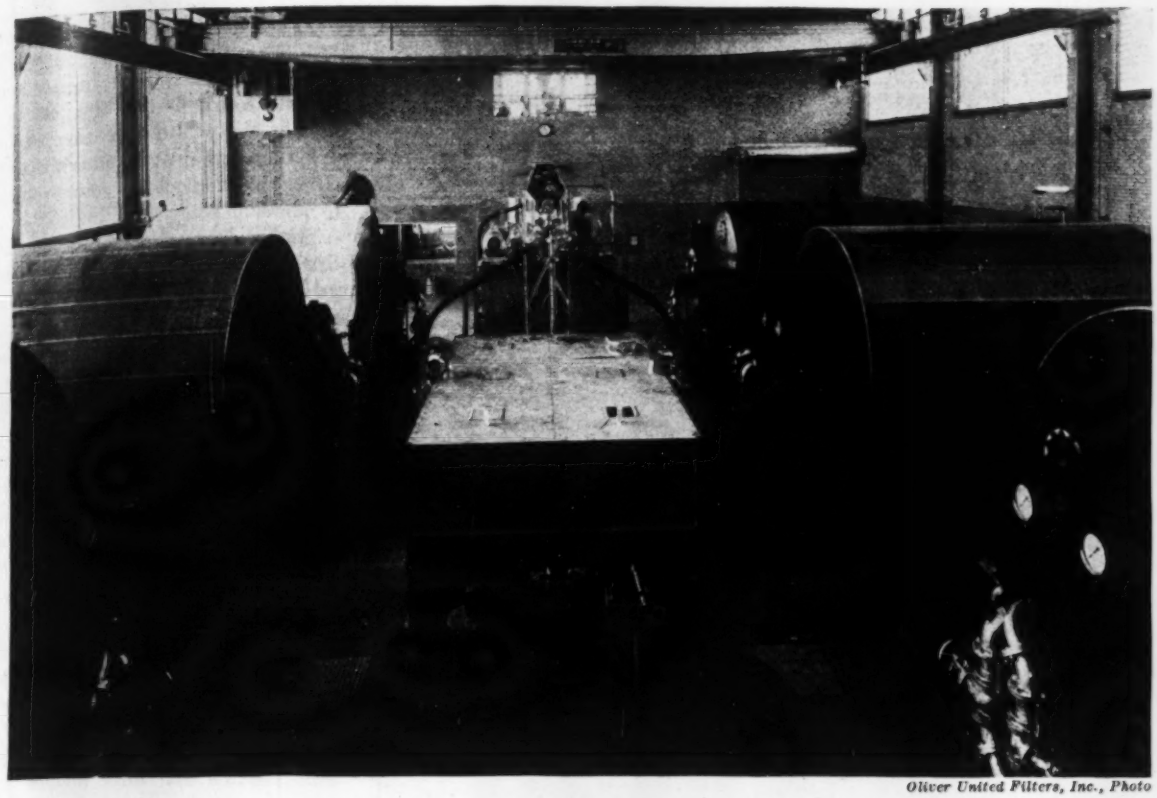
In studying the unit costs on these projects, which are mostly medium and small in size, it appears that in only a few cases was pipe of less than 8-in. diameter used for the main sewers. This practice is in conformity with the engineering specifications of the larger cities where pipe of not less than 8 in. is required for main sewers; the 4 and 6-in. sizes are used only for small branches and house laterals. It was noted that in very few cases was the pipe larger than 24 in. when vitrified clay was employed, because above this size either reinforced concrete or cast iron is preferred. In some instances, contractors bid the same prices on vitrified clay and plain concrete for sizes from 8 to 15 in. In the majority of projects, however, vitrified clay was used in the 8 to 15-in. size range.

An examination of the curves in Fig. 1 shows that as the depth of trench increases, the curves for the different size pipes tend to come together. A reasonable conclusion from this would indicate that as the trenches deepen, the cost of excavation assumes the greatest weight and the differences in cost for the different size of pipe are less apparent since they are absorbed in the item of excavation.

Table II—HOURLY LABOR RATES ON WPA SEWER PROJECTS IN NEW YORK STATE

Location	Section	Common Labor	Bricklayer	Pipe Layer	Machine Operator
Elmira	South-central	0.50	1.50	0.60	1.25
Hempstead, L.I.	New York city zone	0.75	1.89	0.75	1.25
Hudson Falls	North-eastern	0.50	1.25	0.65	1.12½
Youngstown	North-western	0.50	1.50	0.65	1.50

NOTE—The price per foot of vitrified sewer pipe, single strength, delivered in New York City in December, 1938, was $0.29 for 8 in. and $0.57 for 12 in. pipe.



Oliver United Filters, Inc., Photo

FIG. I. SLUDGE FILTERING FACILITIES AT THE MINNEAPOLIS-ST. PAUL TREATMENT PLANT.

Sludge Filtration and Incineration

***Contents in Brief**—Operation of sludge disposal equipment at the Buffalo and Minneapolis-St. Paul sewage treatment plants reveals exceptionally good equipment performance. Results achieved and the manner in which minor troubles were corrected are summarized in papers given at the Central States Sewage Works Association meeting.*

EXPERIENCES with filtration and incineration of sludge at two of the major sewage treatment plants in the country indicate that equipment for this purpose exceeds performance guarantees. An account of operating results and some of the "tune-up headaches" encountered at the Buffalo and Minneapolis-St. Paul plants was given at the annual meeting of the Central States Sewage Works Association on Oct. 12-13, from which the following summary has been prepared.

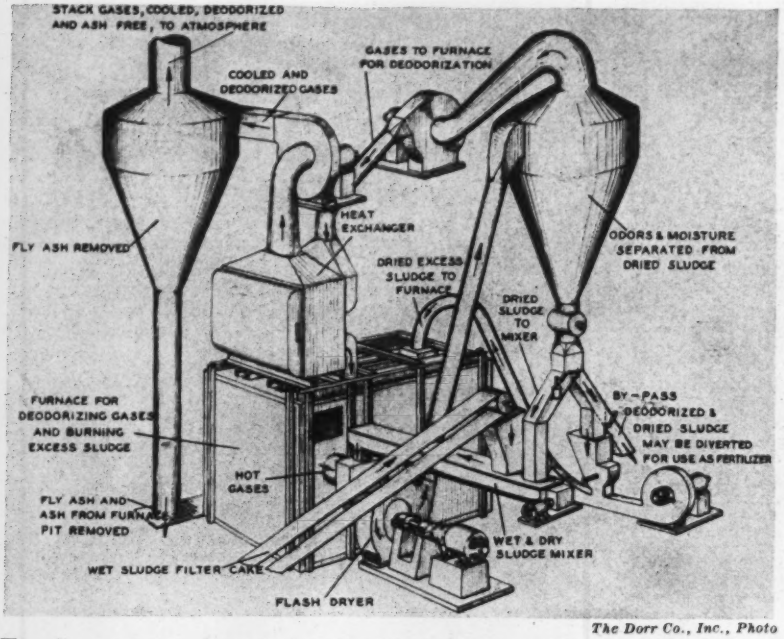
Reporting for Buffalo, where vacuum dewatering filters and flash drying type furnaces are used, C. R. Velzy, works superintendent, said that the highest filter production was 13.4 lb. of dry solids per square foot per hour against a rated capacity of 5 lb. Speaking for the Minneapolis-St. Paul Sanitary District Works, George J. Schroepfer, superintendent, stated that the multiple-hearth furnaces at his plant burned as much as 78.5 tons of dry solids in 24 hours in contrast to a rated capacity of 60 tons.

Operation at Buffalo

Against the background of satisfactory general performance of the Buffalo sewage treatment works Mr. Velzy stated that the following interesting operating experiences have been encountered in sludge disposal.

The sludge tanks providing a storage period of 20 days have been a definite asset. They absorb the irregularities of the daily production of raw sludge and brief interruptions in filtering and incineration. Further, they permit a 6-day operating week and a weekly cleaning and maintenance period. And the gas resulting from digestion in the tank has value as fuel for heat and auxiliary fuel for incineration.

The vacuum filters have given exceptionally good results. At the rated capacity of 5 lb. dry solids per sq. ft. per hour each filter would yield 30 tons of dry solids per day or 100 tons of 70 per cent moisture cake. The highest production for one day from one filter was 220 tons of 63.6 per cent moisture cake which is a total of 160,700 lb. or a rate of 13.4 lb. dry solids per sq. ft. per


STACK GASES, COOLED, DEODORIZED AND ASH FREE, TO ATMOSPHERE
GASES TO FURNACE FOR DEODORIZATION
COOLED AND DEODORIZED GASES
HEAT EXCHANGER
FLY ASH REMOVED
ODORS & MOISTURE SEPARATED FROM DRIED SLUDGE
DRIED EXCESS SLUDGE TO FURNACE
DRIED SLUDGE TO MIXER
FURNACE FOR DEODORIZING GASES AND BURNING EXCESS SLUDGE
BY-PASS DEODORIZED & DRIED SLUDGE MAY BE DIVERTED FOR USE AS FERTILIZER
HOT GASES
FLY ASH AND ASH FROM FURNACE PIT REMOVED
WET & DRY SLUDGE MIXER
WET SLUDGE FILTER CAKE
FLASH DRYER

The Dorr Co., Inc., Photo

Fig. 2. At Buffalo the sludge incineration process provides four cycles of treatment, namely: drying, burning, odor elimination and dust collection.

hour. These favorable filtering rates have been obtained during the first year with less than 10 per cent lime and less than 8 per cent ferric chloride.

One of the operating problems encountered was in connection with the pumping of raw sludge from the settling tank to the sludge tank. The sludge line is a 10-in. pipe, 600 ft. long. Although the normal pressure in this line is between 20 and 30 lb. per sq. in. it was found that the pressure built up to 50 to 60 lb. when pumping at a high rate. Examination disclosed that the pipe was almost filled with grease. Steam and hot water were used to flush out the line after which pressure returned to normal. This raised question whether sludge lines should be made small enough to provide scouring velocities and thus prevent deposits, and whether sludge lines should be of steel with expansion joints to better withstand steaming out.

An interesting and unexpected problem arose from the high rates of filtering. With a filter tending to produce well over 100 tons of cake per 24 hr. it was difficult to operate one filter and one furnace together. Operation of one filter and two furnaces, however, was not so difficult. The high filter rate and the resulting thick heavy cake produced wide fluctuations in the weightometer indicator because of the tendency for the cake to drop on the belt in large pieces with empty spaces between the loads of cake. It would appear that a device serving as a surge bin and feeder would improve this condition. After inspecting an installation of this type at Auburn, N. Y., a device was built and installed on one filter consisting of a bin with a screw conveyor in the bottom. The conveyor is driven through a variable speed drive.

Incinerator abrasion troubles

The major problem in incinerator operation (flash drying type) appears to be the proper organization of maintenance work. This is largely a question of handling abrasion in certain parts of the drying and sludge handling equipment. This abrasion may be due to the presence of about 23 per cent of sand in Buffalo sewage, which is considered high. It was found that the bars in the flash dryer, the blades and casings of certain fans and the elbows in the fuel line would wear through in relatively short periods.

The application of hard surfacing by arc welding has been employed to resist the wear at these critical points. Some progress is also being made toward providing easily replaceable parts where abrasion occurs. It now appears possible that an operating and maintenance routine can be established which will provide that each furnace will operate for a period of about two months and will then be taken off the line for general overhaul with particular attention to the points subject to abrasion.

Sludge disposal operations for the first year at Buffalo were summarized as follows: At the start, solids in the raw sludge averaged 3.46 per cent, which is relatively low, due to the inexperience of the new operator; now the raw sludge contains 9 to 10 per cent solids. Digested sludge has averaged consistently 12 per cent solids. Moisture in the sludge cake has averaged 61.8 per cent and the volatile matter 38.8 per cent. These results were obtained by the use of 9.35 per cent of lime and 2.31 per cent of ferric chloride as average without much change in recent months.

The burning of sludge has been at the rate of 77 tons of filter cake per day with the use of 6½ gal. of oil. For the first three months two incinerators were in use, burning at the rate of 84 tons of cake per furnace per day. The cake contains 38.5 per cent solids which amount to a rate of 32.3 tons of dry solids per day.

Minneapolis-St. Paul plant

A total of 105,315 tons of filter cake with 64.6 per cent moisture content has been produced by the Minneapolis-St. Paul sewage treatment plant since operation started on July 2, 1938, according to George Schroepfer, superintendent. For the past year the quantity of dry sewage solids has averaged 92.6 tons daily, equivalent to 273 tons of filter cake daily. During the nine months from Dec. 1, 1938, when all sludge was filtered and incinerated, the quantity of dry solids has averaged 103.7 tons daily, equivalent to 303.6 tons of filter cake.

In early operation, difficulty was experienced with lime deposition on the filter cloths, and after a period of several months' operation the openings on the screen supporting the cloth had been reduced to less than one-quarter of their original area by calcium carbonate deposits. Finally the screens (they cost $193 each) were removed and sand-blasted at a cost of only $15 per filter, with entirely satisfactory results.

For the entire period of one year the average filter rate was 5.31 lb. per sq. ft. per hour. During the early period when higher chemical dosages were used, the rates were considerably higher, averaging as much as 10 lb. over relatively long periods of time. In addition to the higher operating costs to secure greater rates, the production of a thick cake presented certain operating problems in the conveying of the cake which were undesirable. In view of the fact that the increased power cost by using more filters was insignificant and the extra cost of cloths was small in comparison with the savings in chemicals which could be effected, the desirability of operating with lower filter yields was apparent. In emergencies, or under extreme peak conditions, it may be necessary to use higher chemical dosages to increase the filter rate.

In the early period of operation, cloths generally had to be removed after about 150 hours of usage. The necessity of removal was dictated by the fact that lime "blinding" necessitated higher chemical dosages and more frequent washing, and ripping or rotting at seams required the use of a large number of tin patches (as many as 30 to 40 on a filter) even with this short life. With reduced lime dosage the cloth life has been increased to somewhat over 200 hours. Use beyond that time requires increased use of chemicals that outweighed the cost of cloth replacement, especially in view of reduction in cost of cloth which has been effected. The ability to purchase identical cloths locally at a fraction of their original cost has made it possible to change filter cloths more frequently than was formerly the case. In addition, the new cloths are sewed with a different type of thread and with a lock stitch with the result that difficulties at the seams requiring patching have been eliminated.

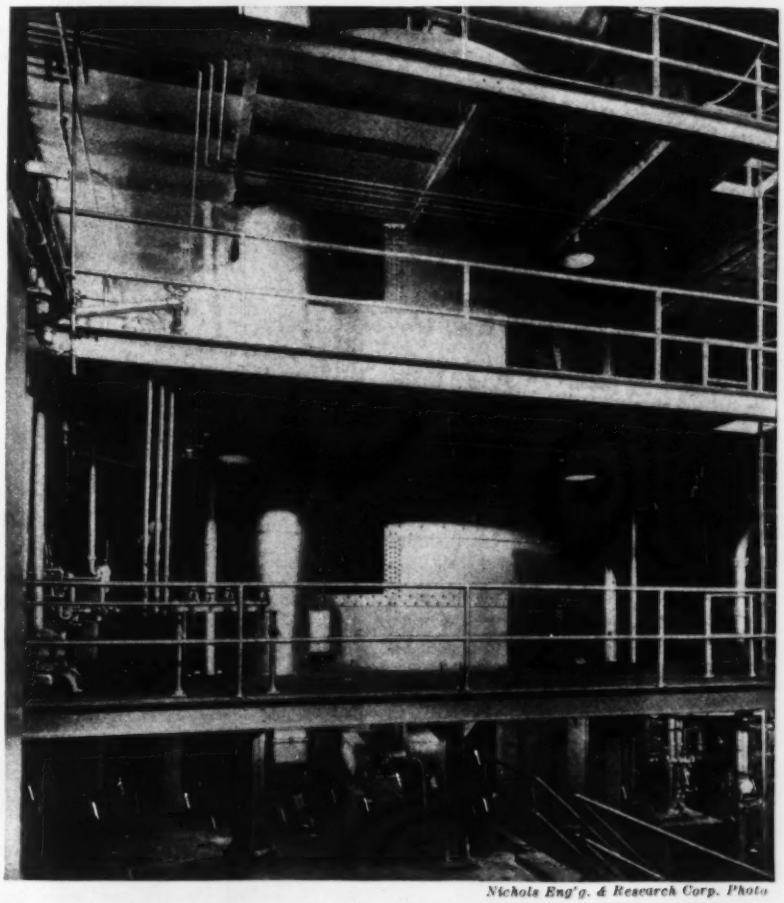
The problem of conveying filter cake on belts presents many difficulties which are sometimes not recognized. Plug-ups are quite frequent with relatively minor restrictions in openings around and over belts and at transfer points. These problems are aggravated with thick cake (heavier than $\frac{3}{8}$ in.) It was found early that large blocks of cake as long as 8 ft. and as wide as the filter drum were broken off as the drum revolved. Various methods of breaking up this cake were considered, resulting in the selection of the simple and effective expedient of installing sloping $\frac{1}{4}$-in. rods on 12-in. centers in the filter take-off plates which cut the cake into ribbons 1 ft. wide which break off irregularly.

An unusual problem which presented itself was the curling of conveying belts carrying sludge cake. Two of seven belts used for this service began to curl downward at the edges after several months of service, in spite of the fact that the carrying idlers for over half of the length of the belt are troughed in the opposite direction. Engineers of three leading belt manufacturers, after analysis of samples of the belt, decided that the cause was grease contained in the sludge which had penetrated the belt cover, indicating the necessity of using oil-resistant rubber on the belts. After ten months of service the curling stopped, and for some reason the belts began to flatten out. The explanation for some of these happenings has not been found.

Multiple hearth incineration

On Aug. 4, 1938 the first incinerator placed in operation (multiple-hearth type) heated up to the point at which the manufacturers' representatives considered it was necessary to shut down in order to insulate the rabble arms on certain of the hearths. Instead of requiring $2,500 of fuel oil a month, as estimated, it was found early that under practically all conditions of operation an excess of heat existed, and no fuel was required for actual incineration.

It was the manufacturers' expectation that the location of burning and the temperatures of cumbustion would be controlled by the use of varying quantities of oil introduced at different points. Instead it was necessary to dissipate heat to the



Nichols Eng'g. & Research Corp. Photo

Fig. 3. Multiple-hearth furnace at Minneapolis-St. Paul, one of three units used for sludge incineration at this plant.

extent of more than 6,000,000 B.t.u. per hour per incinerator. In the beginning, the manufacturers attempted to accomplish this by introducing water into the furnace through sprays. While this was effective, it was considered unsatisfactory by the district engineers to use the large quantity of water required, and after some experimentation the manufacturers installed a bypass to conduct preheated air direct to the stack. In this way air at room temperature could be used for combustion and the quantity of water reduced to reasonable amounts on infrequent occasions.

From July 21, 1938, to Aug. 31, 1939, a total of 102,114 tons of filter cake was incinerated. The average B.t.u. per pound of combustible solids in the sludge was 10,800 and the average volatile solids in the dry sludge cake 56.0 per cent. The sludge cake was reduced by incineration to an ash containing less than 2 per cent volatile matter.

The capacity of each of the three incinerators is 60 tons of dry solids per 24 hours. As much as 78.5 tons of dry solids have been incinerated in one incinerator in a 24-hr. period. Hourly rates considerably in excess of the above have been successfully handled. For the nine-month period from Dec. 1, 1938, to Aug. 31, 1939, the average number of tons of dry solids incinerated per day each of the incinerators has averaged 59.1 tons.

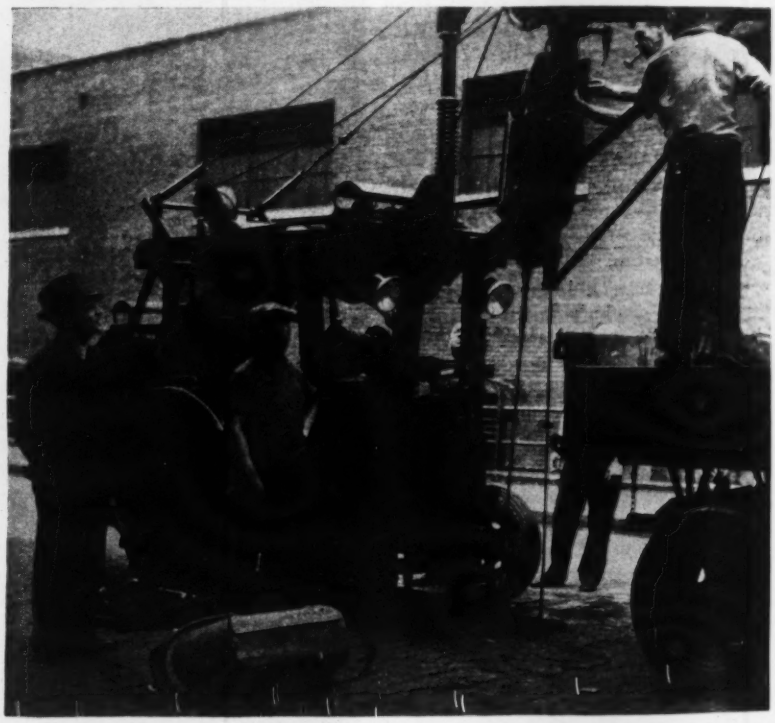
During the nine-month period ending August, 1939, a total of 71,749 gal. of fuel oil was required by the incinerators. Practically all of this was required in bringing furnaces up to temperatures from a cold condition and in holding temperatures in furnaces out of service. The above quantity of oil amounts to an average of 2.4 gal. per ton of dry solids incinerated. Power required for incineration amounted to an average of 16.5 kwh per ton of dry solids.

Sewer Maintenance Hints

Contents in Brief—A definite inspection program coupled with the use of proper cleaning tools are the requisites for effective sewer maintenance. The article tells how to cope with root clogging, sediment deposits and infiltration troubles.

SEWER MAINTENANCE is a continuous job because most sewer systems have such serious faults as bad alignment, flat grades and defective joints and root growths. How to cope with these conditions was the subject of a paper by R. S. Nelle, assistant engineer of the Illinois State Department of Public Health, at a recent meeting of sewage treatment operators at Springfield, Ill. He stated that for effective maintenance it is necessary to have an accurate and detailed set of maps, kept up-to-date and showing the location of all lines, house stubs, manholes, inlets and other appurtenances. A definite inspection schedule is another requirement, forestalling complaints by revealing obstructions and structural defects before service is interrupted. Tree roots, sand, mud, rags and grease are common causes of partial or complete clogging, and many devices and tools are available for clearing the sewers.

Clogging by Roots—The most troublesome trees are locust, poplar, elm and willows, but where there is regular inspection and cleaning, the roots will seldom completely choke the pipe. Scrapers, buckets and root cutters will suffice if used regularly, the tools being put through from manhole to manhole by means of jointed rods or a cable and winch. Minor root obstructions may be removed by placing, on several consecutive days, a handful of copper sulphate crystals into an upstream manhole at times when the flow is small. After repeated doses, flushing will carry out the roots. To eliminate root trouble, it is necessary to un-



Removing sediment from sewers in New York City with a newly developed cleaning machine. A self-closing bucket operated by cables attached to a tractor power unit is pulled through the sewer between manhole openings. It eliminates the need for men to work underground, and operations can be carried on regardless of flow conditions.

cover the sewer and reseal the joints. Use of a copper joint ring, which is said to poison and kill root growths, is claimed as a solution of the problem.

Clogging by Sediment—Cleaning equipment depends on the size of sewer and the nature of the obstruction. Buckets, plungers, hooks, spiral knives, scrapers and other tools are commonly pushed or pulled through. Other tools are equipped with nozzles for water jets to effect flushing and scraping simultaneously. Where the sediment is not too compact, flushing with a fire hose is usually effective, or the sewer may be plugged at a manhole, allowing the sewer to fill and then suddenly removing the plug.

The burlap-covered beach ball seems to have replaced the old "pill" in clearing 12 to 24-in. sewers. The ball is inflated to fit loosely and is forced through by the water or sewage behind it, the jetting action around the ball scouring and cleaning the pipe effectively. Considerable grease is present in domestic sewage, and a brush drag is effective in removing it from the sewers, although flushing is of some value. The sewer ordinance should require hotels, restaurants, etc., to provide grease traps and keep them in proper condition.

Infiltration—Groundwater leakage at defective joints is prevalent in sewerage systems. Sand and mud thus carried in add to maintenance work, but more important is the overloading of sewers and treatment units, resulting in basement flooding, loss of treatment efficiency and high pumping cost. Excessive leakage occurs usually in water-bearing soil or in lines paralleling or crossing streams. Flow observations in the early morning hours will readily reveal leaky sections. Correction of the trouble involves relaying the faulty sewer, using particular care in rejointing. In severe cases cast-iron or other special pipe may be used.

Appurtenances—Frequent cleaning of catchbasins on combined sewers will greatly reduce maintenance. Even if combined and sanitary sewers are flushed during each rain, the accumulation of leaves, grit, sticks and rubbish should be separated at the catchbasins. Intercepting sewer diversions or overflow manholes should be inspected at least once a month to insure proper division of storm and dry-weather flows. At the first indication of nuisance at combined-sewer overflows, the diversion device should be adjusted, if possible, to take a higher dry-weather flow dilution. Manholes should be maintained at street level and never covered by surfacing treatment. Noisy manhole covers, a common source of complaint, may be remedied by placing rubber, canvas or burlap dampers in the frame, by sticking the cover with asphalt at three or four points around the edge, or by purchasing heavier or locking lids. Automatic flush tanks at the upper ends of flat grade sewers should be checked monthly, cleaned if necessary, and the counter readings noted as a guide in adjustment for flushing frequency.

Precautions—Explosion and asphyxiation accidents are not uncommon in sewer maintenance, but are always preventable. Enforcement of proper ordinance will minimize the introduction of explosive substances such as gasoline and naphtha into sewers. However, open flames or sparks should be avoided at or inside manholes. As toxic gases or air deficient in oxygen may be present, the man entering a manhole should always wear a safety belt with the attached rope held in the hands of two men at the surface. Odors must not be depended upon as warnings of dangerous air conditions.

Waterworks Operating Experiences

Notes on peculiar experiences in the operation of Illinois waterworks plants are given in *Over-the-Spillway*, a bulletin of the state department of public health, from which the following particulars are taken:

Rock Island—On Aug. 28 a serious explosion occurred during the finishing of the inside of one of the new clear wells. Its cause has not been determined, but it is assumed that in some way a spark ignited gas from one of the compounds being used to waterproof the inside.

Quincy—Unpleasant taste and odor in the water in September was caused by charred excelsior in the scrubbing tank. The charred excelsior formed a phenol which united with the chlorine to cause the disagreeable taste and odor. Charring was caused probably by tightening of the valves on the compressor, which shot hot gas into the tank at such a rate of speed as to generate sufficient heat to char the material.

Fulton—The water supply became contaminated on Oct. 7 because the reservoir overflow was connected directly to the sewer. With a heavy rain, the sewer was clogged and contaminated water backed up into the reservoir. Warning was spread to all consumers by telephone and through volunteers who drove through the streets shouting to the people to boil all drinking water. It was only through quick action by the superintendent in thus promptly warning the citizens that a very serious water-borne epidemic was avoided.

Manteno State Hospital—A serious typhoid epidemic in August, resulting in 52 deaths and a total of 394 cases, was traced to a leaky sewer whose wastes traveled through the limestone formation forming the water supply source. This was proved by applying salt to the sewer line and making chloride determinations on the water supply. This condition indicates the reason for providing chlorination of all supplies that have their sources in limestone, especially where there are outcroppings and sufficient layers of drift over the limestone.

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Alga Control in Reservoirs

Methods of chemical control of algæ in reservoirs of Illinois waterworks are noted in a bulletin of the state department of Public Health. At Streator and Georgetown, Ill., the treatment consists of the application of copper sulphate in the proportion of about 5 lb. per mg and a superchlorination dosage of 4 ppm, followed by plenty of activated carbon. At Mattoon, Ill., super-chlorination and de-chlorination is used, applying about 4 parts of sodium thiosulphate to 1 part of chlorine for dechlorination after the superchlorination. While some types of algæ are found to develop within 12 hours, the superchlorination seems to hold down the growths.

Notes on Sewage Disposal

A monthly summary of current developments conducted by Willem Rudolfs

SCUM REMOVAL — Floating grease and scum on the surface of sedimentation tanks are a constant annoyance to the operator, cause the tanks to look unsightly and may impair the effluent quality. For a number of years various temporary measures have been used including movable garden hose sprays and stationary nozzles near the outlet of the tanks. Illustrations of operation of 1,360 Link-Belt spray nozzles placed in 16 Imhoff tanks of Cleveland's Westerly sewage treatment plant (*Link-Belt News*, Jan. 1940) shows the automatic skimming of scum and its propulsion to scum boxes located at the end of the tanks.

A fine sheet of water strikes the surface of the tank at a tangent and imparts motion to the particles. Since the length of the tanks is too great for one row of spray pipes to move the scum through the entire length a series of pipes is put across the tank. The force of the spray is sufficient to move the scum from zone to zone. To propel the scum accumulating at the end of the tanks to the lips of the scum box at one side spray pipes are present at right angles to the others. Observations by the writer show this method to be very effective.

HISTORY—Application of domestic sewage for improvement of soil and utilization of water is again extensively practiced and talked about. Sometimes these "new" ideas are thought to be of modern times. It is very interesting that in Pericles' time, about 450 B.C. the poor stony soil of Greece was made to yield more by enriching the gardens and groves about Athens with the sewage of the City. Will Durant, in his book *The Life of Greece*, tells about the sewage brought by a main sewer to a reservoir outside the Dipylon, and led thence by brick-lined canals into the valley of the Cephisus River for agricultural use.

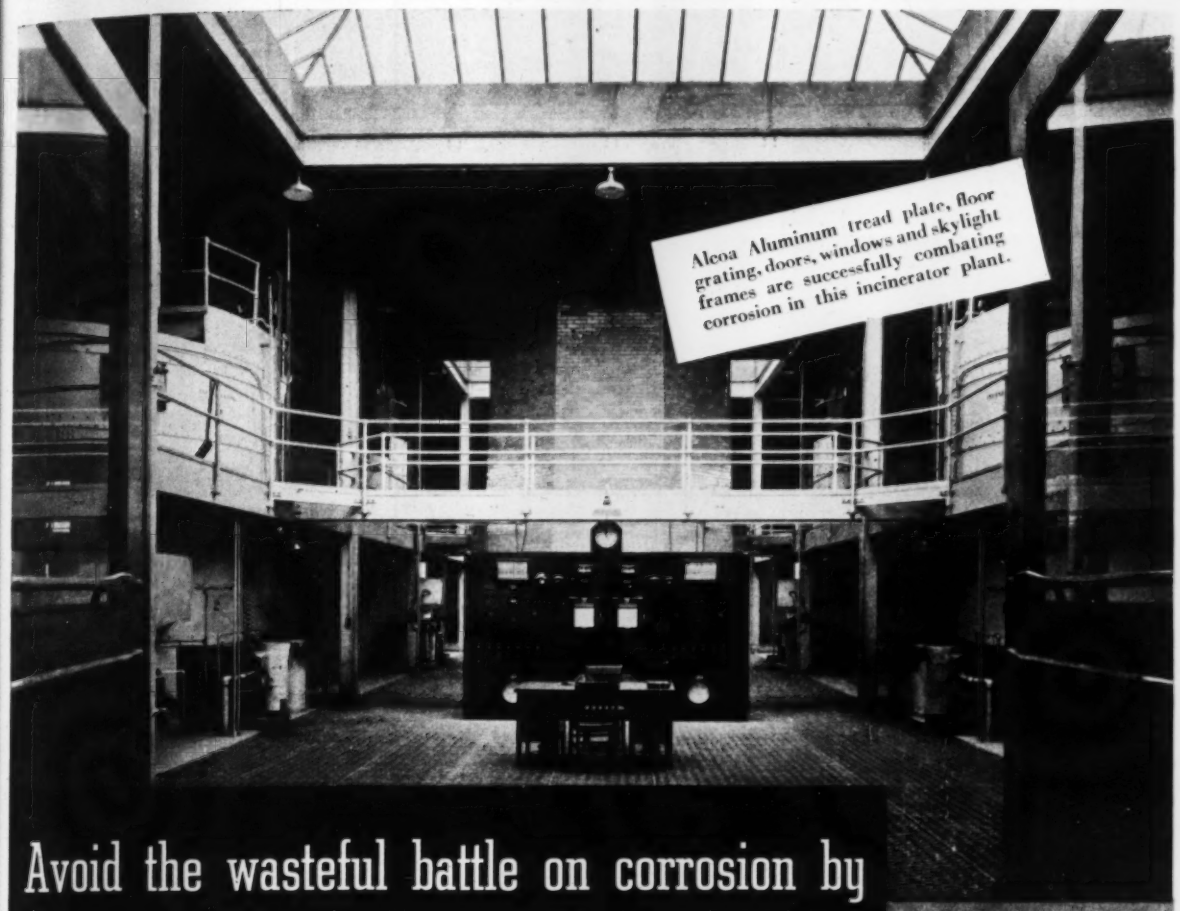
Recently a paper presented before a technical society stated that the watercloset had been invented in 1801. Other sources claim the invention to have been in 1780, in 1822, 1836 and 1854. A few years ago the writer heard the Right Honorable Lord Mayor of South Port, England, at the opening of the International Health Congress, tell the following: "It would make a long story to hark back to the fifteen-eighties when Sir John Harrington, of whom it is recorded, "His nose was sensitive as well as impudent", was made to suffer agonies by the sanitary arrangements in the houses of the great. Suddenly inspired, he invented the watercloset. This was brought to the notice of Queen Elizabeth who, although greatly amused at first, before long saw the practical wisdom of it, and eventually set the fashion for the new contrivance by having one installed in Richmond Palace.

FISH DEATHS—From time to time apparently undetermined conditions cause mass dying of fish in ponds and lakes. If temporary pollution enters the water the reasons may be obvious, but if no known pollution is present the first thought usually turns to fish poisoning. A case of this nature occurred last summer in a shallow lake where large numbers of fish as well as crabs and eels died after a rainstorm. On examination the water appeared greenish on account of algae, and chemical analyses showed an average of 75 per cent saturation of dissolved oxygen. Chemical analyses disclosed no evidence of poisonous substances or excessive quantities of oil.

Further analyses, however, showed that the water had a high oxygen consuming power, due to the presence of decomposition products of vegetable origin. The bottom of the lake was found to be covered with a layer (1 to 2 in.) of actively decomposing vegetable matter probably deposited earlier in the season; this muck produced marsh gas, indicating decomposition in the absence of oxygen. Decomposition of the vegetable matter, together with a reduction of fresh water inflow because of drought, caused a reduction in the available oxygen in the water. While this did not interfere with fish life as long as the muck rested quietly at the bottom, experiments showed that dispersion of the muck into oxygen-saturated water caused a reduction of dissolved oxygen of over 50 per cent in one hour. Fish deaths occurred after a rainstorm accompanied by a change in temperature.

It was concluded that slight changes in temperature of the surface layers of the water caused the bottom muck to be disturbed which, with the aid of the rain, was distributed through the water thus removing the available oxygen rapidly to the point where many of the fish died. A contributory factor was the absence of sunlight which curtailed the action of the green organisms. Recovery of the oxygen saturation to 75 per cent in 24 hours was due to the presence of green algae which manufacture oxygen at a high rate in sunlight, aided by the shallowness of the lake allowing rapid re-aeration, and settling of the muck to the bottom. Rain, which ordinarily helps in introducing oxygen, was detrimental under these conditions.

TAR AND ROAD OIL — Unusual quantities of road oil, tar or gasoline received at biological sewage treatment plants are apt to interfere with the functioning of the various processes. General bacterial action in digestion tanks is retarded, but experiments seem to indicate that eventually more gas may be produced. Microorganisms capable of attacking petroleum and its fractions in either mixed or pure cultures have been obtained from soil by Stone, White and Fenske (*Journal of Bacteriology*, 39, 91, 1940). The organisms are small gram-negative rods which form white, iridescent or yellowish-green colonies on nutrient agar. The organisms work best at temperatures between 20 and 37 deg. C. at a pH of from 6 to 8 and require a plentiful supply of air. The destruction of petroleum products in the activated sludge process or in trickling filters would proceed most rapidly. The findings also explain why tars and oils accidentally entering streams disappear eventually. In general lighter oils are more easily attacked than heavy oils.



Alcoa Aluminum tread plate, floor grating, doors, windows and skylight frames are successfully combating corrosion in this incinerator plant.

Avoid the wasteful battle on corrosion by *Building with Aluminum*

Ordinary metals, unprotected, don't last long in many locations in a sewage disposal plant. True, their life can be lengthened by painting, but *this costs money*. And there are many hidden corners which can't be given adequate protection. Corrosion soon gains a foothold there.

You don't have to provide this protection where Aluminum is used, so operating costs are less. In this sewage incinerator plant, for example, the Aluminum floor grating will retain its original high strength; the Aluminum doors, windows and skylight frames are here to stay. Mighty little attention is needed to keep Aluminum construction safe and looking fine.

For equipment that must be painted, use Aluminum paint, now standard in many sewage disposal plants. You'll get longer life with this "coat of metal protection." And for best results, specify paint made with Alcoa Albron pigment. ALUMINUM COMPANY OF AMERICA, 2108 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

SUPERSTRUCTURE PIT RIVER BRIDGE

OWNER: Bureau of Reclamation, Kennett Division, Central Valley Project, Calif. R. S. Calland, acting supervising engineer.

PROJECT: Construction of superstructure for the combination railroad and highway bridge over Pit River for relocation of Southern Pacific Railroad and U.S. Highway 99. Bridge is located between Redding and Delta, Calif.

CONDITIONS: Government to furnish all materials to be part of completed structure except steel for spans and bents. Shipment of steels from shipping point (Gary, Ind., or Chicago) to Redding and Delta, Calif., to be made on Government bills of lading. Access from existing roads to site of work to be provided by contractor. Safety nets required in superstructure construction. Work to be completed in 585 calendar days. Wage rates are: skilled labor, $1.10 to $1.50 per hr.; semi-skilled, 75c. to $1.10; and common, 75 to 80c. Southern Pacific Railroad and U.S. Highway 99 near bridge site.

BIDS: Two bids were received Jan. 16, 1940, the low, $2,588,354, and $2,750,321. Under low bid Government will be required to transport 20 carloads of equipment to job and 15 carloads from job.

LOW BIDDERS:

1. American Bridge Co., Pittsburgh, Pa. (contract) $2,588,354
2. Bethlehem Steel Co., San Francisco, Calif... 2,750,321

Item	Quan.	Unit Prices (1)	(2)
1. Furn. and erect carbon steel in spans 1, 10, 11, 12 and 13 and bents 1, 2, 3, 4 and 5	2,940,000 lb.	$0.0615	$0.0655
2. As above, in spans 2 to 9 inc	10,710,000 lb.	.064	.069
3. Silicon steel, spans 2 to 9 inc	19,540,000 lb.	.0715	.0711
4. Cast steel and pins and rockers	1,030,000 lb.	.121	.196
5. Constr. railroad floor, incl. timber floor, metal walkway plates fire protect., metal handrails and tracks, complete	L.S.	33,415.00	35,500.00
6. Concrete, highway floor	5,550 c. y	20.00	26.00
7. Spec. finish, conc. surfaces	770 s. y.	1.00	1.25
8. Place reinforcing bars	1,300,000 lb.	.0221	.0144
9. Place rubber water stops in elastic-filler joints	930 l. f.	1.05	.25
10. Place elastic-filler mat'l. in elastic-filler joints	1,560 s. f.	.80	.265
11. Inst. metal handrail, highway floor	420,000 lb.	.021	.018
12. Inst. blast plates and manh. fr. and covers	35,000 lb.	.0165	.017
13. Install electrical conduits	305,000 lb.	.0315	.03
14. Inst. metal ladders and pipe handrails on piers and abutments	7,000 lb.	.0165	.122
15. Inst. metalwork for drainage sys	100,000 lb.	.0315	.093

CONCHAS CANAL NEW MEXICO

OWNER: Bureau of Reclamation, Tucumcari Project, New Mexico. S. O. Harper, acting chief engineer.

PROJECT: Earthwork, tunnels and structures from station 0+00 to station 1,342 + 70 of Conchas Canal, and preparation of aggregates, Tucumcari Project, N. Mex. Work located from 18 to 30 miles northwest of Tucumcari, San Miguel County.

CONDITIONS: Schedule 1 to be completed within 400 calendar days; Schedules 2, 3 and 4 within 700 calendar days; and Schedule 5 within 700 calendar days. Government will furnish cement, sand, and broken rock, reinforcing bars, lumber for permanent installation, asphalt, sewer pipe, elastic filler material, and all other materials for use in completed structures except steel tunnel supports. Contractor to furnish above supports and all temporary tunnel timbering and rock and gravel filler for space back of plate-steel tunnel lining. Wage rates are: skilled labor, $1.00 to $1.25 per hr.; semi-skilled, 55 to 90c.; and common labor 50c. per hr.

BIDS: Sixteen bids were opened Nov. 16, 1939 on Schedule 1 ranging from the low of $562,027 to $1,245,615. Schedules 2, 3 and 4 were awarded together, the low bid being $1,309,582, the high, $1,676,465. Five bids were received on this combination. On Schedule 5, thirteen bids were received ranging from the low of $74,400 to $171,570. Two schedules are recorded in the unit prices below, 1 and 3. In Schedule 3, Gordon Construction Co. was the fourth low bidder, but in the combination basis on which the award was made, they were third, and are so shown below.

SCHEDULE 1—EARTHWORK AND STRUCTURES

LOW BIDDERS:

1. Utah Constr. Co., and Griffith Co., San Francisco, Calif. (contract) $562,027
2. Morrison-Knudsen Co., Inc., Boise, Idaho.... 581,518
3. J. A. Terteling & Sons, Boise, Idaho..... 588,343

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Common excavation, canal	2,000,000 c. y.	$0.11	$0.07	$0.135
2. Rock excavation, canal	213,500 c. y.	.11	.35	.135
3. Excavation for core banks	65,000 c. y.	.12	.12	.15
4. Remove loose rock	600 c. y.	.50	.75	1.00
5. Overhaul	250,000 sta. c. y.	.008	.01	.02
6. Compacting embankments	23,000 c. y.	.25	.15	.18
7. Excav., common, dr. chan. and dikes	10,000 c. y.	.22	.12	.20
8. Rock excav., drain. chan. and dikes	2,000 c. y.	1.35	.60	.20
9. Excav., common, structures	28,000 c. y.	.90	.65	.50
10. Rock excav., structures	7,000 c. y.	.90	2.00	2.00
11. Backfill	160,000 c. y.	.11	.15	.10
12. Puddling or tamping backfill	8,400 c. y.	1.00	.50	1.00
13. Concrete in structures	13,630 c. y.	14.55	18.00	12.50
14. Place reinf. bars	1,768,000 lb.	.016	.017	.02
15. Dry rock paving	4,800 s. y.	2.00	2.00	1.00
16. Erect timber in bridges	66 Mbm	35.00	40.00	25.00
17. Place asph. planks, bridge floors	4,300 s. f.	.125	.15	.10
18. Inst. blow-off valves and conn	10,500 lb.	.05	.06	.10
19. Inst. radial gates and hoists	13,500 lb.	.05	.06	.11
20. Inst. misc. metalwork	400 lb.	.10	.18	.20

SCHEDULE 2—EARTHWORK AND TUNNEL NO. 2

LOW BIDDERS:

1. Jahn-Bressi-Bevanda Constr., Inc., Los Angeles, Calif. (contract) $496,100
2. Thompson-Markham Co., Draper, Utah..... 539,894
3. Gordon Construction Co., Denver, Colo..... 588,560

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Common excav., canal	22,300 c. y.	$0.30	$0.20	$0.30
2. Rock excav., canal	650 c. y.	.60	.50	1.00
3. Remove loose rock above canal	100 c. y.	2.00	1.00	1.00
4. Common excav., structures	100 c. y.	1.00	3.00	1.00
5. Rock excav., structures	10 c. y.	5.00	5.00	2.00
6. Excav., all classes in tunnel	42,700 c. y.	6.50	8.53	8.65
7. Backfill	100 c. y.	1.00	1.00	1.00
8. Puddling or tamping backfill	75 c. y.	2.00	1.00	1.00
9. Concrete in tunnel lining	9,450 c. y.	10.00	7.95	9.50
10. Conc., portal struct. and transitions	150 c. y.	35.00	20.00	18.00
11. Place reinforcing bars	14,000 lb.	.025	.03	.03
12. Permanent steel tunnel supports	826,000 lb.	.07	.06	.09
13. Permanent timbering in tunnel	371 Mbm	80.00	60.00	60.00
14. Steel tunnel-liner plates	219,000 lb.	.07	.06	.07
15. Drill grout holes under 10-ft	1,200 l. f.	1.00	1.00	1.00
16. Place grout pipe and connections	450 lb.	.20	.30	.10
17. Pressure grouting	2,400 c. f.	1.00	1.00	1.00
18. 6-in. tunnel drain	2,000 l. f.	1.50	1.00	1.00
19. 6-in. sewer pipe, cemented joints	100 l. f.	.50	1.10	1.00
20. Dry-rock paving	300 s. y.	4.00	3.00	3.00

Yes, sealed ball bearing sheaves keep lubrication in and dirt out, to prevent excessive wear and prolong the life of the bucket. In addition Blaw-Knox Buckets make generous use of tough alloy steels to avoid excessive dead weight and provide worthwhile savings in rehandling costs. Write Blaw-Knox today for Bulletin 1606.

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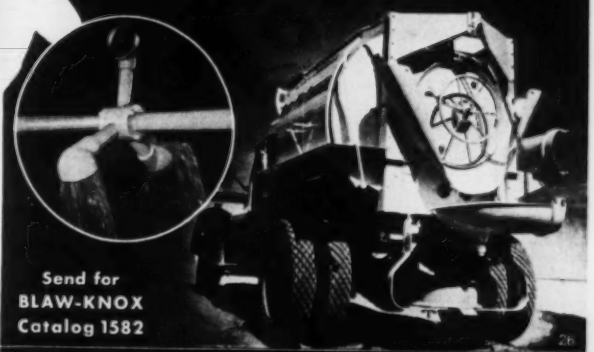
BLAW-KNOX BLAW-KNOX DIVISION • OF BLAW-KNOX CO. • Farmers Bank Bldg. Pittsburgh, Pa.

Digging and Rehandling **BUCKETS**

FAST WATER!

"MAN... That new WATER IMPELLER in BLAW-KNOX TRUKMIXERS puts water into the batch in one-third the time formerly required."

The new, fast water impeller that won't clog; an accurate and dependable water measuring system; superb mixing action—and assurance of dependable continuous operation make Blaw-Knox Trukmixers the popular choice, and the practical buy for you. Study these features before you decide.



Send for BLAW-KNOX Catalog 1582

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BLAW-KNOX BLAW-KNOX DIVISION OF BLAW-KNOX CO. Farmers Bank Bldg. Pittsburgh, Pa.

Agitators and **TRUKMIXERS**

For compacting earth fills—the practical design of Blaw-Knox Sheepsfoot TAMPING ROLLERS appeals to contractors because they give uninterrupted service and meet all modern specification requirements.

The roller units are full floating, on husky frames—built for long, hard use.

Send for complete details and prices.

BLAW-KNOX DIVISION of Blaw-Knox Company
FARMER'S BANK BUILDING PITTSBURGH, PENNA.

BLAW-KNOX *Sheepsfoot* **TAMPING ROLLERS**

SEVEN MATERIALS IN ONE BIN?
"You Bet—this new BLAW-KNOX plant accurately measures and loads aggregates, cement and water into truck mixers."

Blaw-Knox Truck Mixer Loading Plants include overhead storage bins for aggregates and cement; accurate Weighing Batchers for aggregates, cement and water; arranged for manual or automatic operation; complete conveyors for handling materials from cars or trucks to bins, when desired—all properly designed and built to your requirements as an efficient unit for truck mixer loading. See Blaw-Knox Catalog No. 1582.

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BLAW-KNOX BLAW-KNOX DIVISION • OF BLAW-KNOX CO. • Farmers Bank Bldg. Pittsburgh, Pa.

TRUCK MIXER **LOADING PLANTS**

MATERIALS AND LABOR PRICES

Market quotations on construction materials and wage rates reported monthly by ENR correspondents

MARCH construction material prices remain remarkably close to February levels, only minor changes being reported in the list. Short Leaf Southern Pine is 50c. to $1.00 lower on most sizes in Kansas City. Douglas Fir is off $1.00 on 2 x 6-in. size in Chicago and on the 1 x 8-in. size in Kansas City. Pine and fir timbers are up 50c. to $2.00 in Baltimore, and up $2.00 in Montreal.

Portland cement prices remain unchanged. Sand and gravel is 5c. per ton lower in Baltimore. Crushed stone is off 15c. per ton on the 1½-in. size in Detroit. Ready mixed concrete is 25c. per cu. yd. lower in Seattle.

Granite paving blocks dropped $5.00 per M in Chicago. Lime prices are 50c. and $1.00 lower, respectively, for hydrated finishing and pulverized masons in New York.

Common brick is at February levels, but an increase is anticipated in New York about March 15.

Asphalt and tar felt roofing rolls are up 5c. per 65-lb. roll in New York, and slate-surfaced rolls are expected to advance in the middle of the month.

Structural steel shapes are up 10c. per 100 lb. and reinforcing bars are 5c. per 100 lb. higher in Montreal. The latter are 10c. lower in Los Angeles. Dry red lead is 25c. per 100 lb. lower in all 20 cities.

An increase of 12½c. per hr. from the former $1.25 plasterers' rate in Atlanta is the only change in skilled or common labor rates. Common rates have been unchanged since last August.

CEMENT, AGGREGATES, READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT (Per bbl., carload lots, including 40c per bbl. for bags, cash discount not included)			SAND AND GRAVEL (Per ton, carload lots)			CRUSHED STONE (Per ton, carload lots)		CRUSHED SLAG (Per ton, carload lots, f.o.b. plant)		CONCRETE Ready Mixed 1:2:4, 50 c.y. or more, delivered
	Cloth Bags*a*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.90	$2.65	....	$1.75	$1.85	$1.95	$1.65	$1.75	$1.55	$1.65	$7.90
Baltimore	2.31	2.06	1.86	1.70‡	1.70‡	1.20‡	1.75‡	1.75‡	1.75‡	1.75‡	6.50
Birmingham	2.50	2.25	2.05	1.80	1.80	1.50	1.00	1.00	.90	1.15	5.80
Boston	2.75*b*	2.50*b*	2.30	1.10‡	1.10‡	.80‡	1.10‡	1.10‡	....	....	6.75*m*
Chicago	2.60	2.35	2.20	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	1.25‡	1.25‡	....
Cincinnati	2.58	2.33	2.08	1.20	1.20	1.10	1.80	1.80	....	....	6.60
Cleveland	2.29	2.04	....	1.45*i*	1.45*i*	1.45*i*	1.70*i*	1.70*i*	1.70*i*	1.70*i*	6.85*i*
Dallas	2.30	2.05	1.85	2.00*p*	2.00*p*	1.50*p*	1.69*p*	1.84*p*	....	....	6.20
Denver	3.02	2.77	....	1.20	1.40	.90	....	....	....	....	7.25
Detroit	2.15	1.90	1.70	1.30	1.40	.81	1.30	1.45	1.02‡	1.14‡	6.50*i*
Kansas City	2.56	2.31	2.16	1.85	2.30	1.00	1.91	1.91	....	....	7.90*n*
Los Angeles	2.82*b*	2.62*b*	....	1.00	1.00	1.00	1.00*f*	1.00*f*	....	....	5.85
Minneapolis	3.00	2.75	....	1.00*h*	1.00*h*	.25*h*	1.00*h*	1.00*h*	....	....	7.60*j*
Montreal	....	1.75*r*	1.60*r*	....	....	1.25‡	.85‡*c*	1.00‡*c*	....	....	7.60*l*
New Orleans	2.41	2.16	1.96	1.50	1.50	1.25	....	....	....	....	7.25
New York	2.60‡	2.35‡	....	1.40*de*	1.40*de*	.90*de*	1.65*de*	1.75*de*	....	....	7.25
Philadelphia	2.32	2.07	1.87	1.55‡	1.65‡	1.25‡	....	....	1.00	1.00	7.95*k*
Pittsburgh	2.44	2.19	1.99	1.80‡	1.80‡	2.10‡	2.25‡	2.25‡	1.50	1.50	8.75
St. Louis	2.55	2.30	....	1.50‡	1.50‡	1.25/1.50‡	.85*h*	.85*h*	.75*g*	.75*g*	7.50
San Francisco	2.72	2.52	2.20	1.36	1.36	1.36	1.46	1.46	....	....	7.63
Seattle	2.95*o*	2.70*o*	....	1.00*o*	1.00*o*	1.00*o*	2.00*o*	2.00*o*	....	....	7.25

‡ Delivered. *a* 10c. allowed for each returnable bag. *b* 10c. per bbl. off for cash. *c* Plus municipal tax. *d* Per cu. yd. *e* Barge lots alongside docks *f* Crushed granite. *g* F.o.b. Granite City, Ill. *h* F.o.b. plant. *i* Within three miles of Public Square. *j* 5% discount for cash. *k* Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000. *l* Up to 200 cu. yd. *m* 50c. off for cash. *n* 25 c.y. or more. *o* 2% off for cash. *p* 10c. per ton off, cash 15 days. *r* 10c. per bbl. off, cash 20 days.

CASH DISCOUNTS CEMENT to Contractors: truck delivery, 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount 10c. per bbl. for payment within 15 days of date of invoice. Subject discount 10c. per bbl. 20 days in Montreal.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable

	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Buffington, Ind	$1.70	$1.65	Ironton, Ohio	$1.60	$1.55	Richard City, Tenn	$1.80	$1.75
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind	1.70	1.65	Steelton, Minn	1.80	1.75
Hannibal, Mo	1.70	1.65	Norfolk, Va	1.65	1.60	Universal, Pa	1.65	1.60
Hudson, N. Y	1.75	1.70	Northampton, Pa	1.55	1.50	Waco, Tex. (5c. Tax inTex.)	1.75	1.70
Independence, Kans	1.70	1.65	North Birmingham, Ala	1.70	1.65	Montreal	1.55	1.55

PAVING BRICK, BLOCKS, ASPHALT, ROAD OILS—F.O.B. CITY

	PAVING BRICKS AND BLOCKS: Granite per M. lots of 50,000 4x4x8 in.	Brick per M. 3x4x8½ in. carload lots	Wood per sq. yd. 3½ in. 16-lb. treat	PAVING ASPHALT (Per ton, less than 80 penetration): Tank car	Drums	ASPHALT BINDERS—FLUXES (Per gal. 80–300 penetration): Tank car	Drums	CUTBACK ASPHALT (Per ton): Tank car	Drums	ROAD OILS (Per gal.): Tank car	ASPHALT EMULSION (Quick-breaking) (Per gal.): Tank car	Drums
Atlanta	$73.00	$39.35	$2.25	$16.60*e*	$22.83*e*	$0.0645*e*	$0.1165*e*	$0.0684*he*	$0.1207*h*	$0.0634*e*	$0.0644	$0.0684
Baltimore	145.00‡	44.00‡	2.75	14.00	20.00	.06	.09	.065*h*	.115*h*	.....	.....	.....
Birmingham	.....	28.50*j*‡	.....	19.20	25.20	.0797	.1097	.0834*h*	.1334*h*	.....	.....	.....
Boston	90.00	46.50	3.25	14.00	20.00	.06	.09	.065*h*	.115*h*	.....	.09‡	.12‡
Chicago	140.00	49.00	1.80*d*	14.00	18.00	13.00*g*	17.00*g*	.055*h*	.10*h*	.035	.08	.12
Cincinnati	112.00	37.50	.....	14.31	18.31	.10	.....	18.00	.....	.0525	.....	.08
Cleveland	110.00	37.50	2.80	15.25	20.50	.07	.08	.07*h*	.085*h*	.035	.08	.09
Dallas	.....	30.00	.....	13.25	20.30	.06	.103	15.00	24.80	.055	.05/.07	.07/.09
Denver	.....	27.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Detroit	.....	35.00	.....	13.60*f*	18.00*f*	.0678	.108	13.60	18.00	.0545	.0518	.0924
Kansas City	.....	44.00	.....	18.50	23.50	.077	.1075	.077*h*	.107*h*	.057	.11	.15
Los Angeles	.....	50.00	.....	6.50*b*	15.00	6.50*bg*	15.00*bg*	5.50*b*	.....	.0192	.0525	.1125
Minneapolis	.....	.....	1.90*d*	19.20	24.20	.10	.12	19.30	28.30	.056	.....	.....
Montreal	75.00	.....	3.62	14.60	21.25	.105	.1375	.101*h*	.121*h*	.07	.13	.16
New Orleans	.....	.....	.....	14.00*a*	19.00*a*	.055	.085	.06*h*	.09*h*	.....	.078	.....
New York	.....	68.00	2.75	15.00	21.00	.06	.09	.065*h*	.115*h*	.....	.07	.11
Philadelphia	120.00	42.50	2.84	14.00	19.00	.055	.08	.06*h*	.09*h*	.05	.06	.09
Pittsburgh	120.00	35.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Louis	110.00/121.00	37.00	.....	14.00	19.00	14.00*g*	19.00*g*	.06*h*	.095*h*	.04	.09	.125
San Francisco	.....	70.00	.....	6.50	15.00	6.50*g*	15.00*g*	7.00	17.50	.025	.0475	.117
Seattle	.....	60.00*c*	.....	13.71	23.51	.....	24.11*g*	10.11/11.11	23.61/24.61	8.36*g*	.0575*i*	.1308*i*

‡ Delivered. *a* F.o.b. Baton Rouge. *b* Delivered to purchaser's warehouse. *c* 3½x4x8½ in. *d* 2½ in. 6 to 8-lb. treatment. *e* Local reduction due to 20% reduction intra-state class freight rates, only Georgia affected. *f* Mexican. *g* Per ton. *h* Per gallon. *i* F.o.b. Martinez. *j* 3x3½x8½ in.

(Continued on page 86)

KEEPS RUST ON THE RUN

RUST has no more chance of beating Dutch Boy Red-Lead than some grammar school eleven has of trouncing Notre Dame.

And no line in all football history ever "held 'em" the way Dutch Boy Red-Lead does. This paint takes hold and holds fast. Expansion or contraction of the metal does not shake the grip. The reason? *This paint is highly elastic.*

And highly resistant. Not only to moisture but to other common promoters of corrosion — gases, smoke, salt water.

Dutch Boy Red-Lead comes in both paste and liquid form. The latter includes a quick drying type for marine painting and other situations where allowable drying time is short. The pigment is always pure red lead containing more than 97% Pb_3O_4. This assures easier application, higher spreading rate and a uniform film of greater density.

In practically every American industry—on millions of square feet of metal surfaces—this paint has proved its dependability. You take no chances when you specify Dutch Boy Red-Lead.

NATIONAL LEAD COMPANY—111 Broadway, New York; 116 Oak St., Buffalo; 900 West 18th St., Chicago; 659 Freeman Ave., Cincinnati; 1213 West Third St., Cleveland; 722 Chestnut St., St. Louis; 2240 24th St., San Francisco; National-Boston Lead Co., 800 Albany St., Boston; National Lead & Oil Co. of Penna., 1376 River Ave., Pittsburgh; John T. Lewis & Bros. Co., Widener Bldg., Phila.

DUTCH BOY RED-LEAD

(Continued from page 84)

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS ¾-in. billet *b*	RIVETS ½-in. structural	WIRE NAILS Base *d*	SHEET PILING Base	STEEL RAILS Per Gross Ton: Standard	Light	Re-rolled	TRACK SUPPLIES: Angle Bars	Std. Spikes *c*	Tie Plates *c*	Track Bolts
Birmingham	$2.10	$2.15	$3.40	$2.55	....	$40.00	$40.00	$39.00	$2.70	$3.00	$2.15	$4.15
Chicago	2.10	2.15	3.40	2.55	$2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.15
Pittsburgh	2.10	2.15	3.40	2.55	2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.15
Buffalo	2.10	2.15	....	....	2.40	....	....	....	....	....	2.15	....
Cleveland	2.10	2.15	3.40	2.55	....	....	....	....	....	....	....	....
Youngstown	....	2.15	....	....	....	....	....	....	....	3.00	....	....
Detroit	....	2.25‡	....	....	....	....	....	....	....	....	....	....
Gulf ports	2.45*a*	2.50*a*	....	....	2.85*a*	....	....	....	....	....	....	....
Pacific ports	2.70*a*	2.60*a*	....	....	2.90*a*	....	....	....	....	3.00	2.25	....

‡ Delivered. *a* F.o.b. cars dock. *b* Rail steel same as billet prices. *c* Other basing points include Portsmouth, O., Weirton, W. Va., St. Louis, Kansas City, Minnequa, Colo., and Pacific coast ports, on tie plates alone. Steelton, Pa., on spikes alone, Lebanon, Pa., Richmond, Va. charge $18 per c.l. *d* Add switching

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

	STRUCTURAL SHAPES Per 100 lb., base price	REINFORCING BARS* Per 100 lb., ¾ in., base price: 15 tons or over *b* New billet	Rail steel	Add Switch	$/cwt. for Del.	EXPANDED METAL LATH—Per 100 sq.yd., carload lots: Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING—Per 100 s.f., carload lots: 4x16 in., No. 5 & 10 wires	4x12 in., No. 8 & 12 wires	6x6 in. No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
Atlanta	$2.34	$2.39	$2.39	.02½	.10	$21.00	$23.00	$1.82	$1.35	$0.1719	$3.04
Baltimore	3.60	2.85	2.70	.....	.10	21.00	23.00	1.70	1.27	.1611	2.75
Birmingham	2.10*a*	2.15	2.15	.02½	.10	19.50	21.50	1.80	1.34	.1701	....
Boston	3.85	2.73	2.58	$20 C.L.	.10	21.50	23.50	1.76	1.31	.1656	3.14
Chicago	2.10*a*	2.15	2.15	.03	.05	19.00	21.00	1.67	1.25	.1575	2.40
Cincinnati	3.68	2.51*c*	2.51*c*	.....	.05	20.50	22.50	1.66	1.25	.1566	....
Cleveland	3.58*g*	2.15	2.15	.02½	.10	20.50	22.50	1.66	1.25	.1566	....
Dallas	4.75	3.25	3.25	.....	.....	25.00	27.00	1.93	1.42	.1827	....
Denver	4.35	3.95	3.80	.....	.....	23.50	25.50	1.97	1.45	.1863	....
Detroit	3.60‡	2.35	2.20	.....	.10	22.50	24.50	1.68	1.26	.1581	2.66
Kansas City	4.03	2.51*c*	2.36*c*	.0	.05	18.50	20.50	1.78	1.33	.1683	2.86
Los Angeles	3.65*f*	2.55	2.40	.02½	.05	23.00	27.50	1.93	1.42	.1827	3.65
Minneapolis	3.80‡	2.48*c*	2.48*c*	.0	.10	21.50	24.50	1.80	1.34	.1701	2.73*d*
Montreal	3.90	2.70	2.60	.....	.....	26.50	29.00	2.99	2.08	.319	....
New Orleans	4.40	2.52	2.52	.05	.10	21.50	23.50	1.82	1.35	.1719	2.875
New York	3.75	2.39	2.39	.....	.10	20.50	22.50	1.76	1.32	.1665	2.74
Philadelphia	3.55	2.66	2.56	.....	.....	19.50	21.50	1.71	1.28	.1611	2.72
Pittsburgh	2.10*a*	2.15	2.15	.02½	.10	21.50	24.50	1.59	1.20	.1503	2.40
St. Louis	3.47	2.39	2.39	.0	.05	24.00	28.00	1.69	1.27	.1602	2.70
San Francisco	3.35	2.525	2.375	.02½	.10	19.00	25.50	1.93	1.42	.1827	3.25
Seattle	2.70*e*	2.40*e*	.....	.....	.....	25.50	27.50	1.93	1.42	.1827	2.90*e*

‡ Delivered. *a* Mill prices. *b* 5–15 tons, add 15c. 1–5 tons, add 25c. Less than 1 ton, add 50c. *c* 20 tons or over Base. *d* Mill price plus freight. *e* F.o.b. dock. *f* Includes delivery in free delivery zone. *g* Less than 1 ton, add 30c.; 1 to 5 tons, add 10c. * High scrap steel prices cut former 15c. differences between new billet and rail steel in many mills.

PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

	C. I. PIPE Per net ton f.o.b. 6 in. to 24 in.*a*	VITRIFIED SEWER PIPE Per foot, 8 in., s.s.	delivered 12 in., s.s.	ASTM 24 in., d.s.	C13–35 36 in., d.s.	CLAY DRAIN TILE Per 1,000 ft., carload lots, 6 in.	f.o.b. 8 in.	CONCRETE SEWER PIPE Per ft., delivered: ASTM 12 in.	C 14–35 24 in.	WROUGHT STEEL PIPE Full standard weight, *h*: 1 to 3 in., Black %	Butt Weld 3½ to 6 in., Galv. %	Lap Weld Black %	Galv. %
Atlanta	$49.40	$0.26*bc*	$0.468*bc*	$1.8525	$4.68*c*	$85.00	$128.00	$0.45	$1.625	62.2	54.2	59.7	51.2
Baltimore	52.80	.30	.55	2.30	6.80	110.00	150.00	.40	1.60	65.5	57.5	63.0	54.5
Birmingham	45.00	.26	.468	1.854	4.66	85.00	220.00	.40	1.60	62.2	54.2	59.7	51.2
Boston	55.00	.294	.567	2.16	6.15	199.00‡	288.00‡	.50	2.50	64.1	56.1	61.6	53.1
Chicago	53.80	.28	.54	2.25	6.25	100.00‡	150.00‡	.38	1.48	67.0	59.0	63.5	55.0
Cincinnati	52.70	.245	.4995	1.935	5.6375	105.00	170.00	.60	1.70	65.9	57.9	63.4	54.9
Cleveland	54.24	.21	.405	1.575	4.8175	69.00	108.00	.35	1.50	67.8	59.8	65.3	56.8
Dallas	58.20	.265	.477	1.728	4.70	80.00	100.00	.46	1.57	59.9	51.9	57.3	48.3
Denver	60.60	.24†	.52†	2.16†	.....	130.00	240.00	.....	.....	58.4	50.4	55.7	47.2
Detroit	54.24	.147	.2835	1.215	4.70	66.45	111.40	1.62	1.125	66.3	58.3	63.8	55.3
Kansas City	55.12	.30	.54	2.16	5.00	120.00	240.00	.45	1.60	62.9	54.9	60.0	51.5
Los Angeles	55.00	.282†	.508†	2.034†	5.085†	115.50	192.50	1.00	2.00	56.8	47.8	54.3	44.8
Minneapolis	57.20	.24†	.432†	1.728†	4.60†	.....	.....	.70	1.80	64.2	56.2	60.7	52.2
Montreal	60.00	.55	.90	3.15	5.10*e*	135.00‡	260.00‡	.48	1.92	.....	.....	.....	.....
New Orleans	51.38	.26	.48	1.69	.....	150.00	220.00	.37	2.10	62.4	54.4	58.8	50.3
New York	52.20	.32	.63	2.52	6.45	.....	.....	.50	1.20	64.9	56.8	62.4	53.9
Philadelphia	50.90	.21	.405	1.75	5.05	100.00	160.00	.54	1.80	65.3	57.3	62.8	54.3
Pittsburgh	55.60	.245†	.4725†	1.845†	5.4325	97.80	154.20	.85*g*	2.00*g*	68.5*i*	60.5*i*	66.0*i*	57.5*i*
St. Louis	52.48	.24	.432	1.728	3.96	85.00	170.00	.75*j*	1.80*k*	65.1	57.1	62.0	53.5
San Francisco	55.00	.3275*d*	.5895*d*	2.358	5.895	107.25	178.75	.45	2.50	.....	.....	.....	.....
Seattle	55.35	.35	.63	2.52	6.30	72.00	175.00	.45*f*	1.40*f*	.....	.....	.....	.....

‡ Delivered. † F.o.b. *a* B. & S. class B and heavier, C/L lots, 200 tons and over Burlington, N. J. (base) $49.00. Gas pipe and class A, $3 per ton additional, 4 in., $3 per ton additional, 30 in. and larger usually $2 per ton less. *b* Double strength. *c* List to dealer. *d* List. *e* 30-inch. *f* Less 5% for cash. *g* Culvert pipe. *h* Discounts from standard list consumers carload prices, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ½ in., 8½c.; ¾ in., 11½c.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½c.; 4 in., $1.09; 6 in., $1.92. *i* Applies also at Lorain, Ohio, mills. Chicago delivered base is 2½ points less on butt, 1½ on lap. Freight is figured from Pittsburgh, Lorain, O., Chicago Dist. Billing is from point producing lowest price at destination. WROUGHT IRON PIPE: Base price and list prices per ft. same as wrought steel pipe. Discount for Pittsburgh base: Butt-weld—1 in. and 1¼ in. black 24, galv. 19; 1½ in. black 38, galv. 21½; 2 in. black 37½, galv. 21. Lapweld—2½ in. to 3½ in. black 31½, galv. 17½ in.; 4½ in. to 8 in. black, 32½ galv. 20. *j* Reinforced; spec. C 75-37. *k* Reinforced; spec. C 75-37.

(Continued on page 88)

"Our results so far indicate that New RPM DELO can be highly recommended for Buda Diesel Engines, and is a superior lubricant in every respect."

One look at The Buda Company's tough engine tests—and you'll see why! Two engines, a six-cylinder and a four, were broken-in and run on New RPM DELO—many hundreds of hours at full speed. On top of that the six-cylinder Buda was pushed 10% above normal rated horsepower.

But this punishment didn't mean a thing to New RPM DELO! Every piston ring was free—power seal perfect. Yet Buda has found that other oils tested under the same conditions of speed and load would stick rings long before the completion of these tests.

More! Buda's bearings showed no sign of corrosion. And New RPM DELO brought pistons, rings, liners through this severe run smooth and *unworn.*

Users of all types of Diesels as well as leading engine manufacturers are proving the exceptional performance of New RPM DELO. Make money by choosing it for *your* Diesel equipment.

New "RPM" Diesel Engine Lubricating Oil is available everywhere in the gray barrel with the blue head

Order from Your Nearest Distributor as Listed Below:

IN THE UNITED STATES

RPM DELO:
The California Company (Montana only)
Humble Oil & Refining Company
Standard Oil Company (Indiana)
Standard Oil Company (Nebraska)
Standard Oil Company of California
Standard Oil Company of Texas
Utah Oil Refining Company

Diol RPM DELO:
The Carter Oil Company, Tulsa, Oklahoma
Colonial Beacon Oil Company
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey
Standard Oil Company of Pennsylvania

Kyso RPM DELO:
Standard Oil Company (Inc. in Kentucky)

Signal RPM DELO:
Signal Oil Company

Sohio RPM DELO:
The Standard Oil Company (Ohio)

IN CANADA & NEWFOUNDLAND

Imperial RPM DELO:
Imperial Oil Limited

IN BRITISH COLUMBIA & ALBERTA

RPM DELO:
Standard Oil Company of British Columbia Limited

THROUGHOUT THE WORLD

RPM DELO is available through distributors in more than 100 countries.

STANDARD OIL COMPANY OF CALIFORNIA

(Continued from page 86)

LUMBER, TIMBER, PLYWOOD—PER M FT. B.M., CARLOAD LOTS F.O.B.

	SHORT LEAF YELLOW PINE AND DOUGLAS FIR— All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. (Prices in Bold Face) *All Fir planks No. 2 common; Fir timber is No. 1 common. Lengths up to 20 ft. (Prices in italics)* 1x6, S4S	1x8, S4S	2x4, S4S	2x6, S4S	2x8, S4S	2x10, S4S	3x12, R2h	6x12, R2h	12x12, R2h	LONG LEAF Y. P. Merchantable grade up to 20 ft. 2x12, R2h	12x12, R2h	PLYWOOD Rail freight increment (See note for base price) 3/8"	1/2"
Atlanta	**$20.00**	**$20.00**	**$19.00**	**$20.00**	**$20.50**	**$22.00**	**$27.00**	.....	.....	**$37.50**	**$50.50**	$17.75	$21.60
Baltimore	**30.00**	**31.50**	**36.50**	**35.50**	**36.00**	**37.00**	**45.00**	.....	.....	68.00	68.00	17.35*g*	21.15*g*
	32.00	*32.00*	*34.00*	*33.00*	*34.00*	*34.00*	*46.00*	*$46.00*	*$42.00*	.....	.....	.....	.....
Birmingham	**22.50**	**23.50**	**22.00**	**21.00**	**22.00**	**23.00**	**37.00**	**36.00**	**36.00**	.....	.....	16.25	19.85
[1]	25.50	25.50	29.00	27.00	29.00	40.00	60.00	.....	.....	54.00	57.00	.....	.....
Boston	32.00[2]	32.00[2]	34.00[2]	34.00	53.00[1]	63.00[1]	**77.00[1]**	.....	.....	**77.00**	**77.00**	17.35*g*	21.15*g*
	29.00	*29.00*	*34.00*	*34.00*	*36.00*	*36.00*	*46.00*	*46.00*	*60.00*	.....	.....	.....	.....
Chicago	**33.00**	**33.00**	**34.00**	**34.00**	**34.00**	**34.00**	**50.00**	.....	.....	80.00	90.00	13.15	16.05
	37.00	*37.00*	*39.00*	*39.00*	*40.00*	*40.00*	*44.00*	*48.00*	*48.00*	.....	.....	.....	.....
Cincinnati	**31.50**	**33.00**	**30.50**	**31.00**	**32.00**	**35.00**	**44.50**	.....	.....	53.00	56.00	16.25	19.85
	.....	.....	.....	.....	.....	.....	*46.00*	*46.00*	*46.00*	.....	.....	.....	.....
Cleveland	**32.00**	**32.50**	**33.00**	**33.00**	**36.00**	**38.00**	**45.00**	46.00	46.00	80.00	80.00	16.70	20.40
Dallas	**28.50**	**32.00**	**31.50**	**29.00**	**30.50**	**32.50**	**52.50**	**52.50**	**52.50**	63.50	71.00	13.90	16.95
Denver ‡	47.00[4]	45.00[4]	42.00[4]	40.00[4]	40.00[4]	41.00[4]	48.00[4]	60.00[4]	71.50[4]	.....	.....	9.90	12.05
Detroit	**35.00**	**35.00**	**35.00**	**35.00**	**38.50**	**42.00**	**46.00**	.....	.....	43.50	58.00	16.25	19.85
	.....	.....	.....	.....	.....	*46.00*	*47.00*	*54.00*	*54.00*	.....	.....	.....	.....
Kansas City	**28.00**	**29.00**	**29.00**	**28.00**	**29.00**	**30.00**	**35.00**	.....	.....	55.00	60.00	12.25	14.95
	29.00	*29.00*	*30.00*	*28.50*	*29.00*	*30.00*	*35.00*	*39.00*	*39.00*	.....	.....	.....	.....
Los Angeles [a]	*36.00*	*35.00*	*36.00*	*33.00*	*33.00*	*33.00*	*38.00*	*46.00*	*39.00*	.....	.....	9.35*gh*	11.35*gh*
Minneapolis [b]	47.00[6]	47.00[6]	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.05	14.70
‡	*38.00*	*38.00*	*39.00*	*39.00*	*39.00*	*39.00*	*59.00*	*59.00*	*59.00*	.....	.....	.....	.....
Montreal [7]	*46.25*	*46.25*	*40.30*	*40.30*	*40.30*	**58.00**	**87.00**	.....	.....	155.00	165.00	.....	.....
	41.00	*41.00*	*40.00*	*40.00*	*40.00*	*42.00*	*42.00*	*42.00*	*42.00*	.....	.....	.....	.....
New Orleans	**24.00**	**25.00**	**25.00**	**24.00**	**24.00**	**25.00**	**46.00**	.....	.....	62.00	69.00	13.90	16.95
[4]	*29.00*	*29.00*	*32.00*	*33.00*	*35.00*	*34.00*	*36.00*	.....	.....	.....	.....	.....	.....
New York ‡	**38.00**	**39.00**	**37.00**	**38.00**	**38.00**	**39.00**	**42.00**	.....	.....	80.00*f*	82.50*f*	17.35*g*	21.15*g*
‡	.....	.....	*45.00*	*45.00*	*45.00*	*45.00*	*48.00*	*47.50*	*47.50*	.....	.....	.....	.....
Philadelphia	**24.00**	**24.50**	**25.50**	**25.50**	**27.50**	**27.50**	**29.00**	.....	.....	50.00	57.50	17.35*g*	21.15*g*
	35.00	*36.50*	*39.00*	*38.25*	*39.00*	*39.00*	*44.00*	*32.00*	*32.00*	.....	.....	.....	.....
Pittsburgh	**38.10**	**39.90**	**47.05**	**42.00**	**45.65**	**46.90**	**59.70**	.....	.....	.....	.....	17.00	20.70
	51.90	*49.60*	*49.60*	*49.00*	*48.90*	*49.25*	*66.55*	*66.55*	*66.55*	.....	.....	.....	.....
St. Louis ‡	**32.00**	**33.00**	**32.00**	**31.00**	**32.00**	**33.00**	**48.00**	*52.00*	*52.00*	**73.00**	**72.00**	13.90	16.95
San Francisco [d]	*22.50*	*23.00*	*23.00*	*22.50*	*22.00*	*22.50*	*25.50*	*25.50*	*25.50*	.....	.....	7.30*g*	8.90*g*
Seattle	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*26.00*	*26.00*	*26.00*	.....	.....	0.00	0.00

Bold Face type, Southern Pine. *Italics, Douglas Fir.* [1] Long leaf. [2] Roofers' N. C. Pine. [3] Spruce. [4] Native. [5] Western Pine, No. 3 Common. [7] Pine. [8] Norway Pine. ‡ Delivered. *a* Yard prices. *b* Contractors discount in Minneapolis and St. Paul discontinued May 21, 1938. *c* 5M ft. or less. *d* At ship's tackle. *e* 10% discount taken off. *f* Up to 18 ft.

NOTE: Special concrete form grade Fir Plywood, 4' by 8' panels, 5-ply, sanded 2 sides, water resistant glue, carload lots, delivered per 1,000 sq. ft. surface. Seattle base price on 5/8", $77.00; on 3/4", $84.80; price includes oiling and sealing charges. For other centers add rail freight increment from table for proper size. For resin dipped treatment, add $10.50 per M. *g* Lower rate by water shipment. *h* 50,000 lb. minimum.

GLASS, EXPLOSIVES, CHEMICALS

	WINDOW GLASS — Discounts from jobbers list, Aug. 15, 1938, Single or Double Thickness: A quality	B quality	EXPLOSIVES — Per lb. 40% Ammonia Gelatin in 50-lb. cases delivered in 200 lb. lots*
Atlanta	75%	75%	$0.15
Baltimore	83%	82%	.15
Birmingham	89%*d*	85%*d*	.105
Boston	82%	82%	.15
Chicago	79%	79%	.15
Cincinnati	79%	79%	.15
Cleveland	79–10–10%	79–10–10%	.19
Dallas	78%	78%	.165
Denver	76–10%	76–10%	.15*e*
Detroit	79–10%	79–10%	.15
Kansas City	79–10%	79–10%	.155
Los Angeles	86%*d*	88%*d*	.1575
Minneapolis	76%	76%	.155
Montreal	70–10%*ab*		.17†
New Orleans	70%	75%	.16
New York	82%	83%	.20*f*
Philadelphia	82–10%*d*	83–10%*d*	.15
Pittsburgh	79%	79%	.1425
St. Louis	79–10%	79–10%	.155
San Francisco	78%*d*	83%*d*	.155
Seattle	85%*d*	88%*d*	.1575

Price of 60% Ammonia Gelatin is $0.015 per lb. higher than 40%

a Disc. from list Sept. 1939. *b* Also less 6% tax exemption. *d* Discount from jobbers' list Sept. 15, 1928.

* Urban prices influenced by service charges or local storage and delivery regulations, do not consistently reflect quantity prices in less congested areas. *e* F.o.b. Louviers, Colo. *f* In boroughs of Kings, Queens and Richmond, and in Manhattan south of Canal Street, add delivery charge of $6.00 per trip. † F.o.b.

40% Ammonia Gelatin price ranges in other than urban areas, per lb. (except Seismograph Grades)

	C/L 20,000 lb. net	Tons	200 lb. lots
E. of the Miss., except Fla.	$0.105	$0.14	$0.16
W. of Miss., to Rocky Mtn. States, and Fla.	.11 –.12	.135 –.15	.155 –.17
Rocky Mtn. States	.11 –.1325	.13 –.145**	.15 –.165**
Pacific N. W. States	.1075–.115	.1375–.15	.1575–.17
Pacific S. W. States	.1050–.1175	.135 –.1475	.155 –.1625

** F.o.b. Louviers, Colo., or Butte, Mont.

PILES, TIES—F.O.B.

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf— Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.18	$0.195
12 in.— 2 ft. from butt	6 in.	50 to 59 ft.	.225	.24
12 in.— 2 ft. from butt	6 in.	60 to 69 ft.	.23	.255
14 in.— 2 ft. from butt	6 in.	50 to 69 ft.	.24	.265
14 in.— 2 ft. from butt	6 in.	70 to 79 ft.	.28	.275
14 in.— 2 ft. from butt	5 in.	80 to 85 ft.	.40	.415
14 in.— 2 ft. from butt	5 in.	85 to 89 ft.	.42	.482

RAILWAY TIES

Prices f.o.b., per tie for carload lots:		6" x8" x8' Untr.	6" x8" x8' Tr.	7" x 9" x8'6" Untr.	7" x 9" x8'6" Tr.
Boston	Oak	$1.20	....	$1.65	....
	Pine	1.50	$2.25*a*	2.25	$3.20*a*
New York	S. L. Sap Pine	1.10/1.20	1.85	1.50	2.35
	Mixed Oak	1.45	1.95	1.90	2.45
Birmingham	White Oak	.85	1.50*a*	1.35	1.70*a*
	Southern Pine	.55*b*	1.10*ab*	.70	1.30*a*
Chicago	Oak	....	1.65*a*	....	2.25*a*
	Southern Pine	....	1.53*a*	....	2.13*a*
Los Angeles	Douglas Fir	.64	1.38*a*	.90	1.80*a*
Philadelphia	Red Oak	1.10	....	....	2.40*a*
St. Louis	White Oak	1.12	....	1.50	....
	Red Oak	1.12	1.60*a*	1.50	2.03*a*
	Sap Pine or Cypress	1.02	....	1.40	....
San Francisco	Douglas Fir	.90*bef*	....	....	1.95*eg*
Montreal	Birch or Maple	.65	1.05*a*	.75	1.35*a*

Tr.— Treated; Untr.— Untreated. *a* Creosoted. *b* 6" x 8" x 8'6". *c* Empty cell. *d* Zinc. *e* Green. *f* At ships tackle.

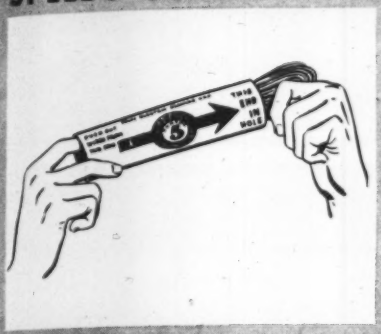
CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York

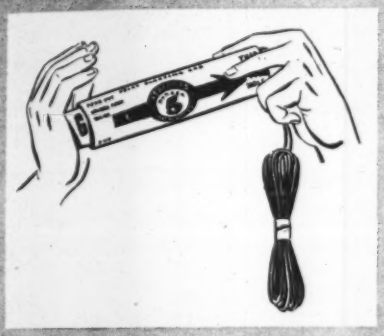
Bleaching powder, in drums, f.o.b. works, per 100-lb.	$2.00–2.85
Chlorine cylinders, liquid, per lb. delivered	.0525
Calcium chloride, 77–80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, delivered, per ton	22.00–35.00
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb.	1.40
Soda ash, 58%, in paper bags, per 100 lb. dense	1.10
Sulphate of aluminum, commercial, in 100-lb. bags, per ton	23.00
Sulphate of copper, in bbl., per 100-lb.	4.60

(Continued on page 90)

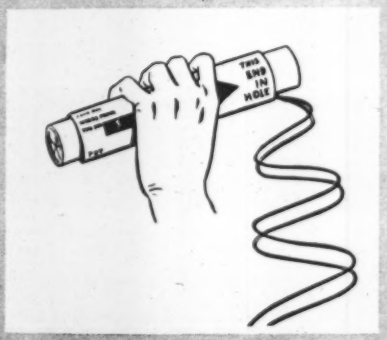
HOW PRIMATUBE SPEEDS UP LOADING



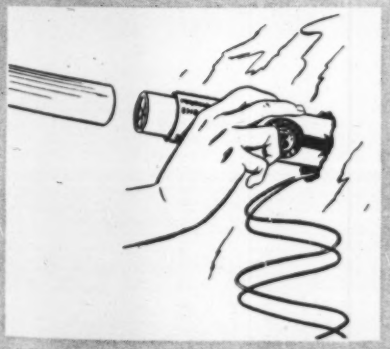
1. Pull the folded cap wires out of the stout tube.



2. The dynamite cartridge is inserted into the tube where it is securely held.



3. The wires are loosened and fall free. The dynamite projects at both ends, making a primer effective in any direction.



4. The arrow indicates direction of insertion in hole. Wires come back neatly, ready to hook up.

A New HERCULES BLASTING AID

HERCULES PRIMATUBE*

Sets the Pace in Tunnel Driving!

On the Delaware Aqueduct, where speed and safety in tunnel driving are all-important, Primatube, a new Hercules development, is setting the pace.

Primatube makes it possible to save valuable minutes in making up primers at the face. Primatube not only speeds up the advance — it contributes to the safety of operations.

The illustrations at the left demonstrate the simplicity and effectiveness of Primatube.

Primatube is another example of the coordination of Hercules field and research engineers to produce more efficient explosives and blasting supplies that result in lower overall blasting costs.

*Reg. U. S. Pat. Off., by Hercules Powder Company J-21

HERCULES POWDER COMPANY
INCORPORATED
940 King Street, Wilmington, Delaware

(Continued from page 88)

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE — PARTITION — SCORED Per M. lots of 2,000 pieces or over, 3x12x12 in.	4x12x12 in.	8x12x12 in.	STRUCTURAL CLAY TILE — LOAD BEARING — SCORED Per M. lots of 2,000 pieces or over, 8x12x12 in.	10x12x12 in.	12x12x12 in.	BRICK Per M. in quantity, Common backing	Straight hard	LIME Per ton, Hydrated finishing	In paper Common hydrated	Carload lot Pulverized or lump
Atlanta	$90.00	$100.00	$185.00	$220.00	$230.00	$240.00	$12.50	$16.00	$26.50	$17.00	$17.00
Baltimore	74.00	80.00	165.00	190.00	240.00	290.00	13.00*k*	16.00*k*	18.50	14.50	2.50*m*
Birmingham	80.00	85.00	160.00	191.00	252.00	288.00	13.50	16.50	18.11	12.35	1.66*o*
Boston	82.10*a*	87.60*a*	164.20*a*	186.10*a*	243.20*a*	277.90*a*	17.00*i*	20.00*i*	19.00	12.50	3.10*p*
Chicago	68.10	72.60	135.90	185.70	234.90	268.10	11.00	12.00	16.40	14.40	12.20
Cincinnati	61.40	65.30	121.90	141.50	187.30	215.20	16.00	16.00	15.90	13.00	.....
Cleveland	56.50	60.00	112.50	135.00	182.50	209.50	16.00	16.00	15.00*j*	12.00*j*	2.75*j**m*
Dallas	62.50	67.00	135.00	162.00	177.00	263.00	11.50*i*	13.50*i*	19.00	15.00	.95*n*
Denver	84.80	95.40	152.70	178.20	212.00	227.90	13.50	17.00	28.00*j*	17.00*j*	35.00*j*
Detroit	68.90	73.50	137.80	175.50	232.00	265.00*e*	15.70	17.00	13.50	11.75	12.75
Kansas City	64.50	66.50	86.00*c*	125.50	159.75	186.25	14.00	24.00	19.10	12.80	10.70
Los Angeles	73.50†*r*	89.50†*r*	128.00†*r*	210.00†*r*	368.00†*r*	460.00†*r*	13.00	15.00	16.50	.....	17.50
Minneapolis	66.70	71.20	122.50	141.30	149.30	209.40	13.10	15.10*g*	21.00	16.00	19.00
Montreal	77.20*a*	77.50*a*	142.50*at*	76.00*a*	165.80*a*	248.70	20.75	28.00	23.50	17.00	11.00
New Orleans	72.00	72.00	135.00	162.00	210.00	260.00	14.00	.....	18.30	12.08	14.10
New York	87.00	93.00	128.00*c*	193.30*h*	238.80*h*	295.60*h*	14.50*u*	.....	19.00	14.00	17.50
Philadelphia	80.50	85.90	161.10	193.30	238.80	295.60	15.00*s*	18.00*s*	15.50*q*	9.55*q*	12.05*j*
Pittsburgh	58.40	62.40	116.85	124.00	153.00	193.75	17.00	25.00	17.90	15.40	2.55*m*
St. Louis	62.00	88.00	120.00	180.00	234.00	280.00	16.00	17.00	22.00	18.00	2.30*m*
San Francisco	84.00	94.50	225.00	.....	.....	.....	14.00	17.00	.55*o*	.40*o*	2.05*m*
Seattle	100.00	110.00	220.00	.....	.....	.....	17.50*f*	17.50*f*	20.00*s*	20.00*s*	20.00*s*

† F.o.b. *a* Smooth. *b* Carload lots delivered to job. *c* 6 x 12 x 12 in. *d* Not load bearing. *e* 48 lb. tile. *f* Less $1.00, ½ cash 15 days, balance 30 days. *g* Selected common. *h* F.o.b. Perth Amboy, N. J. *i* 50c per M. off for cash. *j* LCL. *k* $1.00 discount if paid in 10 days. *l* Lump. *m* Per bbl., 180 lb. *n* Per sack 100 lb. *o* Per bbl., 200 lb. *p* 280 lb. bag. *q* 25-ton cars. *r* 5% discount 10 days. *s* 2% off cash. *t* 5½ x 8 x 12. *u* Price rise expected about Mar. 15.

PAINT, ROOFING—F.O.B. CARLOAD LOTS

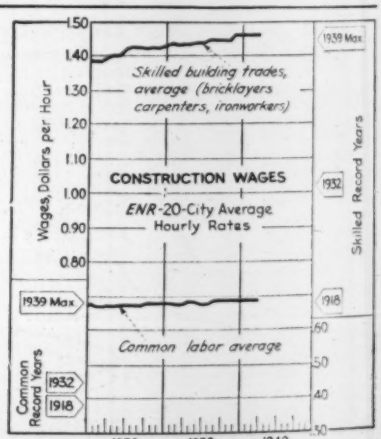
	RED LEAD Per 100 lb. in 600-lb. (Approx.) Dry *a*	WHITE LEAD bbl. Per 100 lb. in oil	READY-MIXED PAINT Per gal., drums Graphite *b*	Aluminum *c*	Ferric Oxide *d*	ROOFING SUPPLIES Carload lots f.o.b. factory— Rolls, slate surfaced, 85–90 lb., per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating per gal.	Tar pitch 350 lb. bbl. per ton
Atlanta	$9.00	$13.125	$1.30	$2.25	$1.20	$1.71	$1.65	$1.65	$0.36	$26.00
Baltimore	8.75	12.75	1.70	2.45	1.95	2.20	2.75	2.75	.45	27.50
Birmingham	9.00	13.125	2.68	2.75	1.85	1.92	1.77	1.77	.45	27.00
Boston	8.75	12.75	1.70‡	2.20‡	1.75‡	1.70‡	1.80*h*‡	1.80*h*‡	.45‡	20.00‡
Chicago	8.75	12.75	1.96	2.63	1.68	1.45*h**f*	1.53*h**f*	1.53*h**f*	.26*f*	21.00*f*
Cincinnati	8.75	12.75	1.65	2.85	1.55	2.40	2.39*h*	2.39*h*	.36	21.00
Cleveland	8.75	12.75	1.90	2.60	1.60	1.68	1.55*h*	1.55*h*	.35	21.00
Dallas	8.75	13.50	1.88	2.11	....	2.75*h*	2.60*h*	2.70*h*	.275	34.00
Denver	9.25	13.25	1.65	2.40	.17*l*	2.45	4.00	3.00	.35	18.00
Detroit	8.75	12.75	2.00	3.00	1.75	2.40	2.75	2.75	.35	27.50
Kansas City	8.75	12.875	2.15*g*	2.40*g*	1.67*g*	1.93	2.09	2.09	.25	25.00
Los Angeles	9.00	13.25	1.60	2.25	2.30	2.10	1.50	....	.45	....
Minneapolis	8.75	12.875	....	....	....	1.68*i*	1.50*h**i*	1.50*h**i*	.29	21.00
Montreal	9.25	9.00	2.25	2.80	2.35	2.53	1.68	1.78	.70	1.68*k*
New York	8.75	12.75	1.88	2.55	1.60	1.68*m*	1.50*h*	1.50*h*	.23	24.00
Philadelphia	8.75	12.75	....	....	....	1.92*e*	1.99*h**e*	1.99*h**e*	.41*e*	21.00
Pittsburgh	8.75	12.75	1.05	1.95	.80	1.95	1.94*h*	1.94*h*	.34	26.00
St. Louis	8.75	12.75	1.90/2.00	2.60/2.85	1.60/2.00	1.55	1.50	1.50	.235	21.00
San Francisco	9.00	13.00	1.80	2.75	1.10/2.00	1.66	1.90	1.90	.325	20.50
Seattle	9.00	13.25	1.80	2.60	....	1.81	1.30/2.00	1.75	.35	28.00*j*

‡ Delivered. Note: Red lead in oil 50c. higher than white lead in oil. *a* Red lead prices change frequently due to pig lead price changes. *b* U. S. War Dept. Spec. 3–49A. *c* ASTM Spec. D266–31. *d* 80% minimum ferric oxide. *e* Subject to 25% discount. *f* Distributors' price to contractors. *g* 5 gal can. *h* Per roll, 65 lb. *i* Minneapolis and vicinity. *j* Asphalt pitch. *k* per 100 lb. *l* per lb. *m* Price rise expected about Mar. 15.

SKILLED AND COMMON WAGE RATES—PER HOUR

	Bricklayers	Carpenters	Struct. Iron Workers	Hoisting Engineers	Plasterers	Common Labor Building	Common Labor Heavy Const.
Atlanta	$1.25	$1.00	$1.375	$1.00/1.25	$1.375	$0.40/.50	$0.40/.50
Baltimore	1.50	1.25	1.65	1.50	1.25	.5625	.5625
Birmingham	1.50	1.125	1.25	1.125	1.00	.30/.40*a*	.30/.40*a*
Boston	1.50	1.375	1.50	1.625	1.625	.60/.85	.60/.85
Chicago	1.70	1.625	1.70	1.70	1.70	1.025	1.025
Cincinnati	1.625	1.45	1.525	1.00/1.525	1.625	.60/.75	.60/.75
Cleveland	1.625	1.375	1.50	1.50/1.75	1.50	.90	.90
Dallas	1.50	1.00	1.25	1.00	1.50	.40/.50	.40/.50
Denver	1.65*b*	1.50*b*	1.43*b*	....	1.50*b*	.718*b*	.718*b*
Detroit	1.50	1.25	1.50	1.50	1.55	.60/.75	.60/.75
Kansas City	1.625	1.375	1.50	1.50	1.575	.85	.50
Los Angeles	1.25	1.10	1.375	1.375	1.50	.625	.625
Minneapolis	1.375	1.25*d*	1.50	1.40	1.50*e*	.85	.85
New Orleans	1.50	1.20	1.50	1.50	1.40	.40	.40
New York	1.90*b*	1.75*b*	1.925	2.00*b*	2.00*c*	1.031	.875/.95
Philadelphia	1.65*b*	1.25	1.65	1.50	1.565	.60	.60
Pittsburgh	1.75	1.50	1.50	1.25	1.75	.80	.70
St. Louis	1.50	1.25/1.50	1.75	1.75/2.00	1.58/1.75	.45/.875	.45/.875
San Francisco	1.75*c*	1.25*f*	1.50	1.50	1.60*c*	.81	.65
Seattle	1.60*c*	1.25	1.50*c*	1.50*c*	1.60*c*	.90*c*	.90*c*
Montreal	.80	.70	.75	.65	.80	.45	.40

a PWA. *b* 7 hr. day. *c* 6 hr. day. *d* 35 hr. wk. *e* 30 hr. wk. *f* Working under "stop-gap" agreement.



ENR Skilled Average: (Bricklayers, Carpenters, Ironworkers) **$1.465**
ENR Common Average: $0.685